Uniform with this volume
and in the same
series

BRICKWORK

ROOFING

CONSTRUCTIONAL DETAILS

PLANNING AND DESIGN

JOINERY

PLUMBING

QUANTITY SURVEYING

HOUSE REPAIRS

ELECTRICITY IN THE HOUSE

GAS IN THE HOUSE

BRICKWORK

By
E. L. BRALEY, M.R.San.I.
Chief Examiner in Brickwork to the City of London Institute.

ENGLISH UNIVERSITIES PRESS LTD.
LONDON

PRINTED AND BOUND IN ENGLAND
FOR THE ENGLISH UNIVERSITIES PRESS LTD.,
BY HAZELL, WATSON AND VINEY LTD., AYLESBURY

GENERAL EDITOR'S FOREWORD

THE AIM of the Teach Yourself Building series is to assist those who are desirous of acquiring information concerning building methods and practice.

It is not intended that these books will take the place of textbooks or recognised courses of study at Technical Colleges, but they should appeal to all students of building because each volume has been written by a specialist in his own particular subject.

The series covers almost every branch of the building crafts and allied professional practice.

In placing before the public this comprehensive work on Building, no apology is necessary for continuing to describe and illustrate traditional methods of building construction, because it is of vital importance that the layman, who desires to become acquainted with building technique, should be instructed in the basic principles of building.

There is really very little difference between traditional methods of building and the form of construction which has been developed to meet the requirements of the immediate post-war era. As pre-fabrication and standardisation will be the main features in the construction of post-war buildings, these methods and materials have been described and illustrated within the framework of this series, but no attempt is made to theorise on their comparative values.

The text has been written in a clear, concise and interesting manner, and the constructional details throughout the series are portrayed by clear line diagram drawings.

In this volume the author has outlined in a concise and practical manner the fundamental processes relative to the craft of Bricklaying. The text and illustrations clearly explain the correct way to " set " the bricks, the process of making mortar, the use of the various tools and every detail of the craft of Bricklaying.

No attempt has been made to deal with the technique of brick bonding, because the constructional aspect of Brickwork is dealt upon and fully illustrated in the book *Constructional Details*, a companion volume in the Teach Yourself Building series.

CONTENTS

CONTENTS

CHAPTER I

THE PRINCIPLES UNDERLYING BRICK-BUILDING

Introduction

A BRICK is best described as "a building unit."

It may be made of burnt clay, of concrete, of mortar or of a composition of sawdust and other materials; in shape it is a rectangular solid and its weight is from 6½ to 9 lb.

The shape and convenient size of a brick enables a man to grip it with an easy confidence and, because of this, brick-building has been popular for many hundreds of years. The hand of the average man is sufficiently large to span across the width of a brick and the arrangement of a man's hand and arm is such that he is able to handle more than 500 bricks in an eight-hour day.

It is necessary, therefore, for the "would-be" brick-layer to practise handling a brick until he can control it with complete mastery and until he is able to place it into any desired position without it slipping through the fingers and being prematurely dropped.

Mixing of Mortar

When this stage has been mastered the learner will approach towards the second step which comprises the mixing, gauging and handling of mortar.

To make mortar it is necessary to combine a dead filler (some inert hard material) with a live agent (matrix) and mix together with water. This live agent may be any one of the following materials : Portland cement, hydrated lime, blue lias lime, or fresh lump lime, and the filler may be fine sand, pit sand, shore sand, or the

"finings" of crushed gravel. The technical term for the former is the matrix whilst the latter is known as the aggregate.

Method of Holding a Brick

By placing the hand over the surface of the upper bed of the brick and placing the thumb centrally down the face of the brick with the first joints of the fingers on the opposite face, the brick may be securely handled. Assistance is afforded by protecting the thumb and the fingers with leather pads which also prevent the unnecessary wearing away of the skin, which results from handling rough bricks or gripping the bricks with too much force.

Details of a Brick

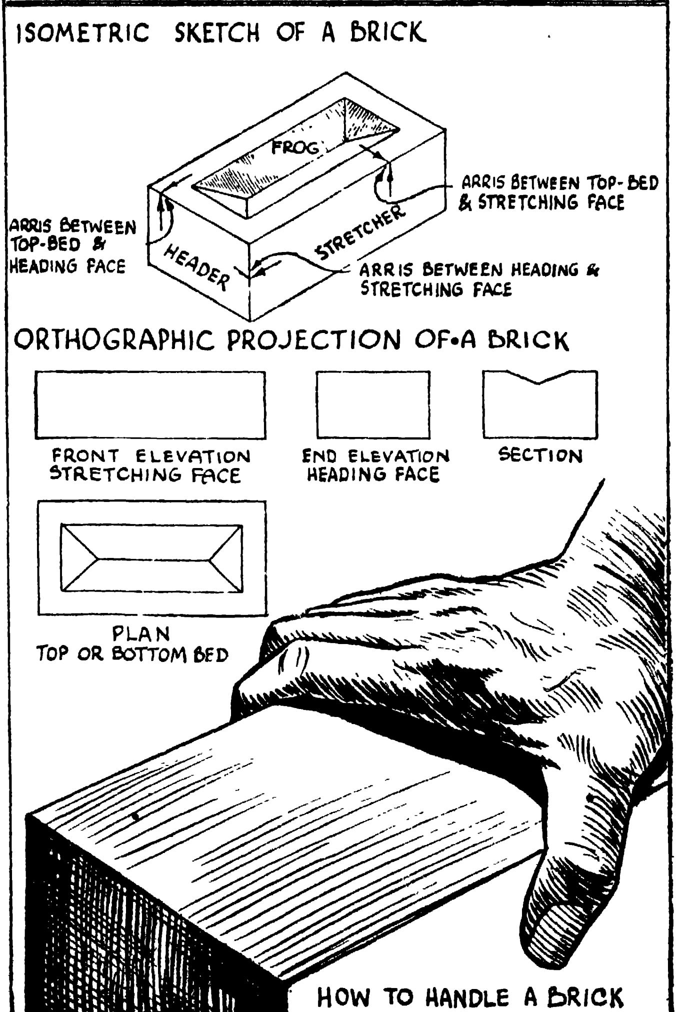
The opportune moment has now arrived to discuss bricks more fully and become intimately acquainted with them. At the outset a definition of a brick was given and it is now desirable to enlarge upon that early description.

If a brick is held in the hand it will be seen that it has six different surfaces, viz., three pairs of similar sides between the same parallel lines. These surfaces are known respectively as the top and bottom beds, the right and left stretching faces and the front and back heading faces (*see* Plate I).

When the position of the brick is changed, then the stretching faces are back and front when built into a 4½-inch wall, and front and inside in a 9-inch wall. Similarly, both the heading faces can only be seen when built into a 9-inch wall, whereas only one of the stretching faces can be seen.

Taking this statement a little further, it will be seen that walls having an even number of bricks in their width will show the same face of the brick on both sides of the wall in the same course. In other words, headers are placed

PLATE I. PARTS OF A BRICK



immediately behind headers in walls of two or three bricks in thickness.

Walls of an odd half-brick in thickness will show different faces on the two sides of the walls in the same course. For instance, if one face of a 14-inch wall shows a stretcher, then the other face will show a header as headers are placed immediately behind stretchers.

Brick-sizes

A brick is almost twice as long as it is wide, and it is three times as long as it is high. A " snap "-header is half as long as the full length of the brick, a " closer " is a quarter as long and so on, and a " brick on edge " is a third of the length of a brick (*see* Plate II).

Thus, we say, when dealing with the size of a brick, " Its length should equal twice its thickness (or width) plus one mortar joint," and that its height should be as laid down by the B.S.S. for clay bricks.

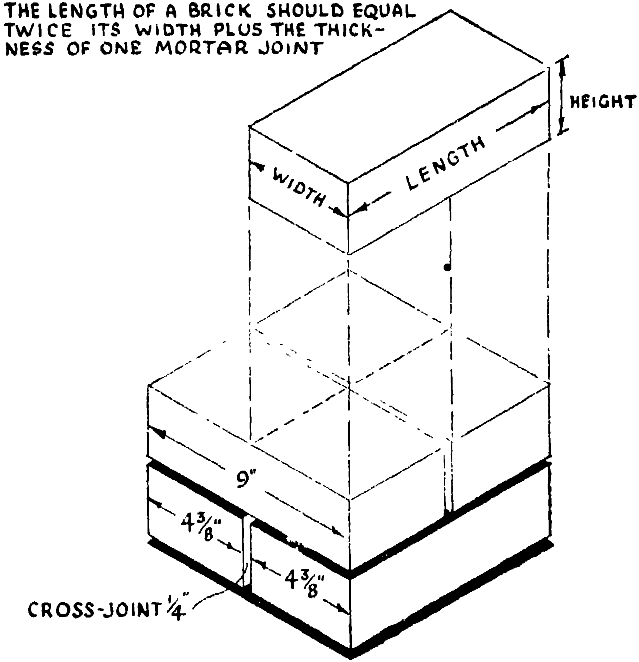
In the North of England, in Scotland and in Ireland the usual height of the bricks is $2\frac{7}{8}$ inches, or what is known, nominally, as a 3-inch brick; sometimes this is increased to $3\frac{1}{8}$ inches and, in special cases, up to $3\frac{3}{8}$ inches. The standard height for bricks in the southern half of England is $2\frac{5}{8}$ inches.

Variations in the sizes of bricks must be strictly limited to $\frac{1}{8}$ inch--either way--in width or length, but the height must remain constant. Nominally, a brick is 9 inches long, $4\frac{3}{8}$ inches wide, and $2\frac{7}{8}$ or $2\frac{5}{8}$ inches in height. When connecting new brickwork to that which is already built, it is very important that the height, or gauge, of the existing brickwork is carefully measured.

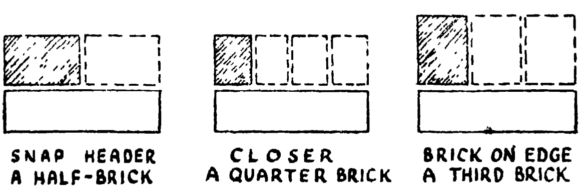
Gauge four or more courses of brickwork until they reach an even measurement, and from this finding will be determined the height of one course of brickwork which will be the thickness of one brick plus the thickness of one bed of mortar. For example, if eight courses measure 2 feet 3 inches and the bricks are 3 inches thick, then the bed-joint is $\frac{3}{8}$ inch.

PLATE II. SIZES OF A BRICK

RATIO OF THE WIDTH OF A BRICK TO ITS LENGTH



RATIO OF THE PARTS OF A BRICK TO ITS LENGTH



The Proportions of a Brick

All brick-building is done to a repetitive pattern, therefore a brick is made of such dimensions that its faces are capable of being factorised.

This is illustrated by a few examples on Plate II.

Thus we said previously, when dealing with the size of a brick, that its length should equal twice its width plus one mortar joint, and that its height should be such that, when four bricks are placed on top of each other with regulated mortar joints between them, they should equal 1 foot.

The foregoing height of four courses to 1 foot applies chiefly to that part of England south of Birmingham, because, as already stated, in the North of England, Scotland and Ireland thicker bricks are used, and the gauge is said to be considerably stronger. From this it will be obvious that for new work the builder must ensure that the bricks to be used do not vary in length or width for more than $\frac{1}{8}$ inch either way.

When connecting new work to old work, it is very important that the height—or gauge as it is called—is carefully measured so that the level of the courses may be maintained.

Making a Gauge

Measure four courses of the new work, built as a trial sample, and ascertain if they work out to an even measurement of 1 foot in the South of England and 13 inches in the North of England. Next, measure the height of four (nominally $2\frac{5}{8}$ inch and $2\frac{7}{8}$ inch) bricks, placed one on the top of the other without mortar, or dry as it is called in the trade, and the difference between the two measurements when divided by four will give the thickness of each mortar joint.

This process is known as "finding the gauge" (*see* Plate III).

Having ascertained this height, it must be used as a constant for all the brickwork throughout the job.

To arrive at a gauge, it is necessary to decide upon the thickness of the parallel horizontal or bed-joints. Such a decision will depend upon the type of brick used and the character of the work in hand.

A very well-known standard type of brick is the " Fletton " brick which has been made in a machine under severe pressure. These bricks are very regular in shape and size, with smooth beds and keen sharp angles or arrises.

When set to a bed-joint $\frac{3}{8}$-inch thick, these Flettons, which are nominally $2\frac{5}{8}$ inches thick, can be laid with ease to a gauge of four courses to 1 foot.

On the other hand, " Lancashire Wirecuts " are not so regular in shape and size, and are nominally $2\frac{7}{8}$ inches thick. The usual gauge at which these bricks are set is "seven courses to 2 feet," and the bed-joint is 31/56 inch—which may appear to be excessively thick. Another common gauge for the thicker brick is "four courses to 13 inches " in which the bricks are set much tighter to a joint of $\frac{3}{8}$ inch.

Too much emphasis cannot be placed on this process of making a gauge and adhering to it, for reasons which will be explained later.

To mark the gauge upon a staff, measure the over-all dimension such as four courses 1 foot, or seven courses 2 feet, upon a straight-edge or piece of board. Within this portion draw a line at any angle to the edge of the board and upon it set off as many equal divisions as there are courses in the gauge. Join the end of the measured distance required for the gauge, with last division set out upon the line previously mentioned.

Lines are now drawn parallel to this from every equal division to indicate the thickness of each course on the arris of the straight-edge or staff.

The foregoing is the easiest practical method of setting out a staff, for it will be appreciated that with an ordinary 2-foot rule it will be almost impossible to measure 31/56 of an inch.

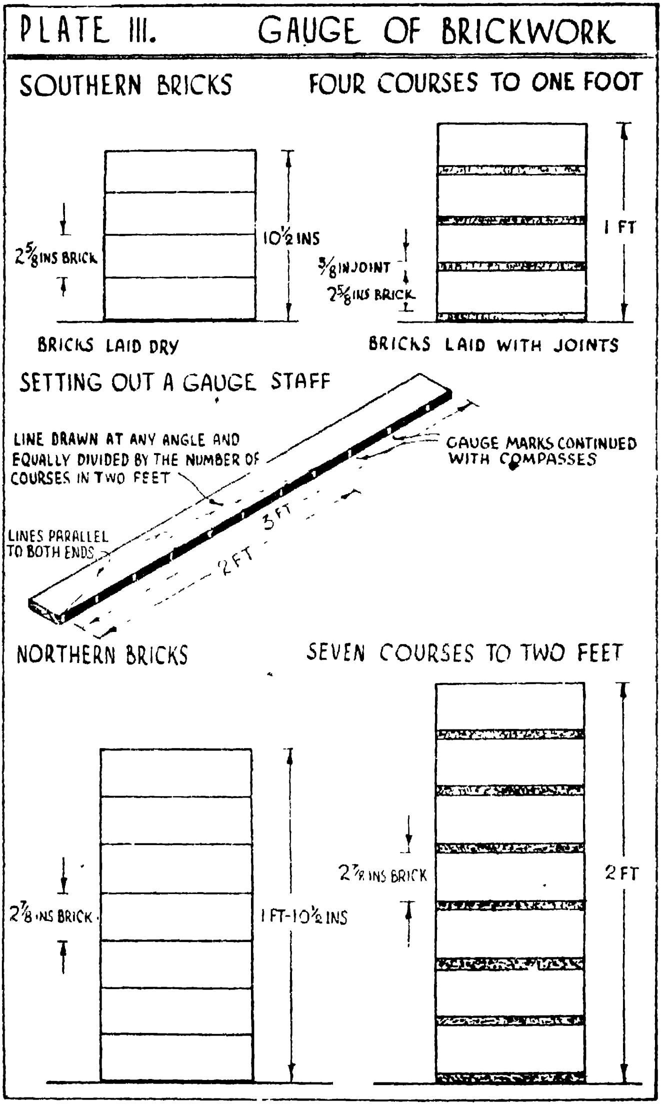


PLATE III. GAUGE OF BRICKWORK
SOUTHERN BRICKS
FOUR COURSES TO ONE FOOT
2⅝ INS BRICK
10½ INS
⅜ IN JOINT
2⅝ INS BRICK
1 FT
BRICKS LAID DRY
BRICKS LAID WITH JOINTS
SETTING OUT A GAUGE STAFF
LINE DRAWN AT ANY ANGLE AND EQUALLY DIVIDED BY THE NUMBER OF COURSES IN TWO FEET
GAUGE MARKS CONTINUED WITH COMPASSES
LINES PARALLEL TO BOTH ENDS
3 FT
2 FT
NORTHERN BRICKS
SEVEN COURSES TO TWO FEET
2⅞ INS BRICK
1 FT-10½ INS
2⅞ INS BRICK
2 FT

Having divided the gauge into the required number of equal parts, mark off the thickness of a brick (with a pair of calipers), the margin thus remaining being the equivalent of the mortar bed.

There is always a tendency to put more mortar between the bricks than is really necessary; for instance, an excess of 1/16 inch on each course for a " lift " of one " scaffold " means that the building will be 2½ inches out of level. Moral — pay strict attention to the gauge.

Function of Bricks and Mortar

More often than not the layman seems to think that the inherent tenacity of the mortar underlies the strength of the wall. This conception is correct, or partly correct.

You will remember that when you inform your friends that you are about to build a wall, they will ask of you, " What keeps the bricks together in a wall ? " and you reply in a guileless manner, " Mortar ! " whereupon you may probably be astounded by the retort, " Mortar keeps the bricks apart." Actually, you are nearer the truth than your friends.

Mortar, however, does not supply all the strength required in a well-built brick wall. This strength is largely dependent upon what is known as bonding.

Definition of Bonding

Bonding simply means the principle of connecting bricks together according to a set pattern. There are too many kinds of bonds, or designs, in practice to be able to deal with them all thoroughly in this particular book, but those bonds which are in common use will be explained.

On looking at a basket, you will notice the manner by which the willows are intertwined under and over. It is the same with the warp and the weft of a woven fabric.

This process of securely fastening one strand against the other is similar to bonding, which is another method

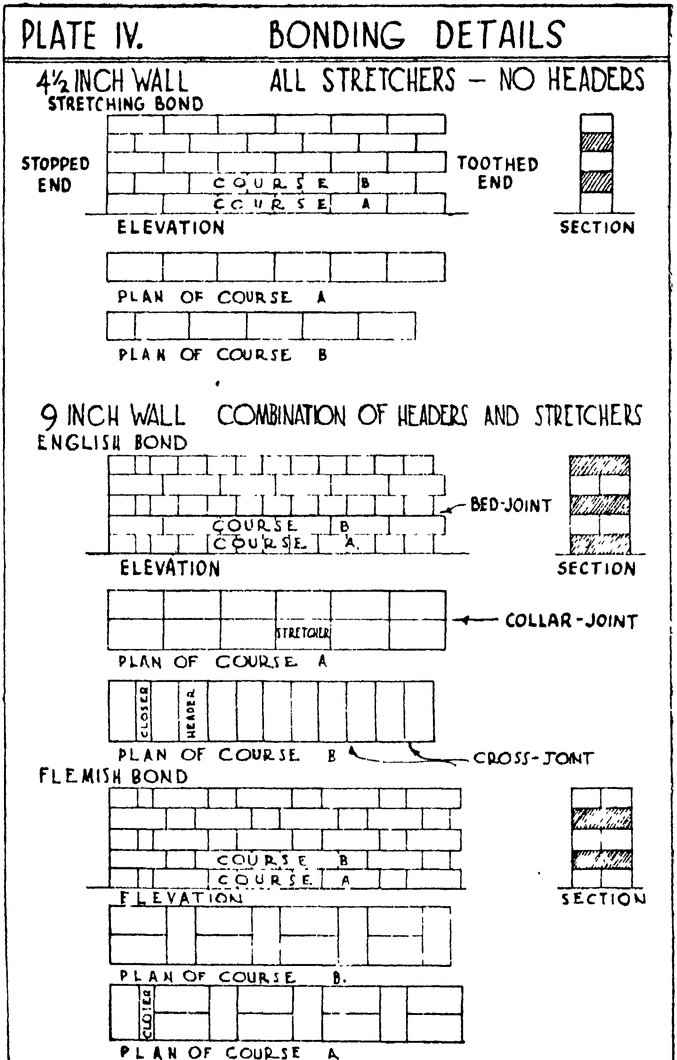


PLATE IV. BONDING DETAILS
4½ INCH WALL
STRETCHING BOND
ALL STRETCHERS – NO HEADERS
STOPPED END
TOOTHED END
COURSE B
COURSE A
ELEVATION
SECTION
PLAN OF COURSE A
PLAN OF COURSE B
9 INCH WALL
COMBINATION OF HEADERS AND STRETCHERS
ENGLISH BOND
BED-JOINT
COURSE B
COURSE A
ELEVATION
SECTION
STRETCHER
COLLAR-JOINT
PLAN OF COURSE A
CLOSER
HEADER
PLAN OF COURSE B
CROSS-JOINT
FLEMISH BOND
COURSE B
COURSE A
ELEVATION
SECTION
PLAN OF COURSE B.
CLOSER
PLAN OF COURSE A

of tying or interlocking together, as adapted to brick-building.

To accomplish this, we must ensure that one brick rests upon two or more bricks, and that two or more bricks rest upon one brick.

Many patterns may be produced by the foregoing arrangement according to the correlation of the bricks in a wall. Bonds are formulated according to the way that the bricks are placed in the wall.

If, for instance, a wall is only half a brick ($4\frac{1}{2}$ inches) thick, then obviously the bricks will be laid lengthwise in the wall, and this arrangement of the bricks is known as "stretching" bond. On the other hand, if the wall is one brick (9 inches) thick, the arrangements of the bonding must of necessity become more complicated.

In walls which are more than $4\frac{1}{2}$ inches thick, the bricks must be placed not only lengthwise as "stretchers" but crosswise as "headers."

Some of the most common brickwork patterns are those known as "English" bond, "Flemish" bond and their "Garden Wall" derivatives (*see* Plate IV).

Definition of Bed-joints and Cross-joints

Before dealing with specific bonds in detail, the joints or mortar spaces between the bricks will be considered.

Normally, bricks are "laid on their flat"—which is their largest surface—and the intervening space between the two opposing horizontal faces when filled with mortar is known as the bed-joint.

The mortar space between the contiguous ends of the bricks is called the cross-joint, and the longitudinal space in the centre of the wall is termed the collar-joint.

Controlling the amount of mortar needed to fill the regulated joints calls for a considerable amount of skill, experience and practice.

An insufficient amount of mortar will mean that the

joints will be too thin, whereas too much mortar will result in the joints being too thick.

Thereby hangs the tale, for it is an accepted fact that the art of judging the amount of mortar needed for the bed-joint is a veritable bricklaying secret.

Now we must go back slightly to what we might have considered in the first place—that is, the material known as mortar.

Mixing Lime Mortar

Mortar is a mixture, as we have already stated, consisting of a matrix and an aggregate which is mixed with water. This combination of materials sets after a given period and becomes an integral part of the wall.

The simplest way to make mortar is to place three or four barrowloads of sand on a mixing board or stage, or on some good hard ground, and arrange the material so that the centre is left open.

Next, take a half-hundredweight bag of hydrated lime and soak the lime in a barrel containing three parts of water, so that the lime and water form the consistency of cream when properly mixed. Into the hole in the centre of the heap of sand pour the fluid lime (*see* Plate V).

By holding the spade vertically and taking a portion of the sand—about 3 inches by the width of the spade—gradually push the sand back into the liquid, allowing the lime to be absorbed by the sand until the whole of the mixture has been overturned towards the centre of the stage.

Continue the process by turning the combined sand and lime first to one side and then to the other, taking care not to get each turning into such a position that it cannot be separated.

If during this process the mixture becomes too stiff, and the process of turning it over becomes increasingly difficult, a little more water may be added to the mixture.

This process of incorporating the lime and sand into one mass is very important—in fact, it is far more important

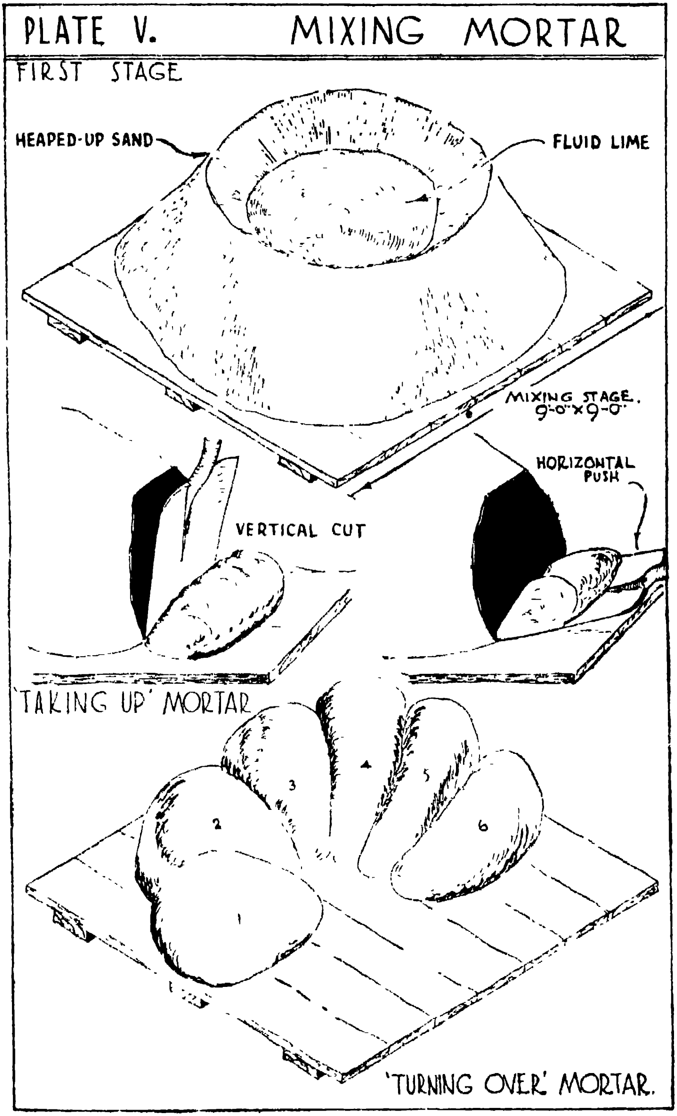


PLATE V.
MIXING MORTAR
FIRST STAGE
HEAPED-UP SAND
FLUID LIME
MIXING STAGE. 9'-0"×9'-0"
HORIZONTAL PUSH
VERTICAL CUT
'TAKING UP' MORTAR
1
2
3
4
5
6
'TURNING OVER' MORTAR.

than the addition of extra water which will only alter the workability of the mix.

Mortar made with hydrated lime can be allowed to stand for a considerable length of time before being " retempered " and made ready for use.

Most lime mortars can be revivified by the addition of a little Portland cement when being retempered. This process of adding fresh materials to accelerate the setting power of the mixture is known in the trade as " gauging."

The only lime mortars that cannot be retempered owing to their strong setting powers are those in the hydraulic lime group. Mortar can be made from fresh lump lime which, of course, must first be slaked.

This may be accomplished by immersing the lime in a box containing water and running the liquid off into a pit formed of sand or boards. After a time the fluid will solidify and become lime putty.

In this plastic state it can be used in a manner similar to that described as for hydrated lime.

A much simpler way is to make a hole in the centre of the dry sand-heap and pack the pieces of lime into it. Then cover the lime over with more sand.

Pour over the heap several buckets of water and leave the materials for a few days to become thoroughly soaked. By that time the lime will be slaked and the mixing can be proceeded with as before.

Mixing Cement Mortar

Another kind of mortar can be made by combining Portland cement and sand but in this case the two ingredients should be thoroughly mixed together in a dry state by turning over twice and shaking the materials together as they fall on to the stage. This procedure is repeated as the materials are wetted and the mortar is now ready for use.

A perfect mixture can be obtained by carrying out this

process, although it must be remembered that cement mortar must be used immediately after mixing because, once the initial set has begun, cement mortar is little more than useless and therefore should not be used.

There are some people who think that Portland cement mortar consisting of one part Portland cement and three parts sand is more workable and has a greater ultimate strength by mixing half of the quantity at the first stage of the mix and thus making a gauge of six to one. When required for use the remaining portion of cement is added and the gauge is restored to the original three to one mix.

Although this method of gauging mortar is sometimes adopted in practice, it is not a desirable one and as such it is not to be recommended.

Similarly, there are objections to strengthening and accelerating lime mortar by the addition of Portland cement, but these objections can be overruled as the advantages far outweigh the disadvantages.

Damp-proof Courses

Bricks and mortar are undoubtedly the stock-in-trade of the bricklayer, and whilst there are hundreds of types of these two materials, there are several other materials with which a bricklayer must become acquainted.

Most prominently situated among these other materials are those used as damp-proof coursing media.

As is to be expected, damp-proof materials must be inherently impervious to moisture, therefore it is natural to expect that slate, tar, pitch, bitumen and asphalt will be amongst the list of selected materials.

Other special materials employed by the bricklayer are mastic and oil used for pointing around wooden frames, fireclay for setting firebricks and furnace work, hair-mortar for pargetting flues, and so on.

Concrete is another material with which the bricklayer has to work, consequently he must learn how to control

both the mixing and depositing of this—the most versatile and adaptable of all building materials. Fine concrete is sometimes used for finished floors and the various materials needed to provide different finishes must be thoroughly understood by the bricklayer as part of his trade.

CHAPTER II

A BRICKLAYER'S TOOLS

Spreading the Mortar

HAVING dealt with the materials used in bricklaying it now remains to consider how we should place them together so as to form a wall, and this is the crux of the whole business.

Firstly, we must learn how to pick up the mortar and then, secondly, to put it down—or as the bricklayer says, "to spread it."

Before one attempts to lay a brick, one must learn to pick up a trowelful of mortar, and this undoubtedly is a most difficult accomplishment.

To become proficient a great deal of practice is needed for it is only by actually going through the several motions that the wrist will become so supple that the proper degree of balance can be sensed and the correct hold of the trowel developed so that the proper strength of the grip can be ascertained.

The Bricklayer's Trowel

As the "laying" trowel is the most important of all the tools a bricklayer needs for his work, we will now consider its several parts and their relation to the controlling of the mortar.

Examine a trowel and it will be seen that it consists of a handle and a blade. The wooden handle of the trowel is fastened to the steel blade by means of a cranked shank. This shank passes right through the centre of the handle and is called the tang.

At the shank end of the handle is fitted a metal ferrule the object of which is to prevent the end of the wood forming the handle from splitting. At the other end—on "Northern" pattern trowels only—is a "button" washer

which is intended to prevent the trowel spinning around in the handle when the blade becomes loosened by wear.

The " London " pattern trowel has a shorter tang which is not drawn completely through the beechwood handle, nor is it secured by a washer.

There are four parts to a trowel blade, namely, the point or toe, the heel and the two shoulders. These terms are self-explanatory. For instance, the toe is used to make the furrow in the " spread " mortar and for putting the finish on to the joint or pointing. The shoulders are eccentric, the right shoulder being slightly larger and heavier than the one on the left so that because of this the heavier side is used for knocking the bricks into position and, also being thicker, it has a greater resistance to wear; as well as this, the trowel being thrown out of balance is easily spun in the hand.

Ability to spin the trowel in the closed hand is an essential acquirement in the art of bricklaying. At the opposite end to the toe is the heel which is the point where the cranked part of the tang is welded to the sheet steel blade, thus forming the lift to the trowel.

Quite a number of bricklayers use the laying trowel for purposes other than the spreading of mortar such as for cutting bricks and similar abusive actions; these practices are not to be encouraged as the trowel is not intended for this purpose.

The Brick-hammer

Second in importance amongst the tools used by a bricklayer is the hammer—the brick-hammer—a most adaptable tool. It consists of a head and a shaft. In practice there are two kinds of hammers - an old pattern and a new pattern, the later type having been copied from the Americans.

The old-fashioned hammer was slightly longer at the chisel-pointed, or cutting, end than at the hammer end. This hammer has many advantages such as a perfect

balance, a concentrated cutting blow with the chisel end, a substitute for a lump-hammer, and as a plumbing hammer. Its disadvantages are that it is, comparatively, heavy, and that when it is used for cutting bricks the force of the blow is too great to be resisted by a brick held in the hand. Bricks to be cut with this type of hammer should be held just above the left knee and supported by the left hand.

The short-headed or "Yankee" type of hammer is about two-thirds of the weight of the long-headed pattern and is considerably restricted in its use, but it has the useful advantage of being used to cut a brick whilst it is held in the hand and in front of the body.

When the amount of cutting is considerable—say when "lining up" to a gable—it is much less fatiguing to use the heavier hammer. Another point worth remembering is that the head of the long-headed hammer will reach behind the plumb-rule and any overhanging bricks can be knocked back without disturbing the plumb-rule in any way.

Personally I prefer the old-fashioned hammer to the popular Yankee type mainly on account of its heavier weight and perfect balance. A further point to remember is that the short hammer is mass-produced, and consequently the metal does not withstand the wear and tear that the individually blacksmith-made long hammer will without losing the temper of the steel and the consequent blunting of its point.

Brick-hammers are used to take away the parts of the brick that are left when the lump-hammer and bolster have not made a clean cut, and so also, of course, is the "scotch" or "scutch" hammer used for a similar purpose.

The sketches shown on Plate XV indicate the processes of cutting bricks with a brick-hammer and with a scutch. Also the lower sketch of Plate IX indicates the advantages of the longer patterned brick-hammer when used in conjunction with the plumb-rule.

The Brick Scutch

Almost every bricklayer's tool is made in two styles; this we have seen in the London and Northern patterned trowel as well as the Yankee and old-fashioned brick-hammers, and now we shall discuss the two distinct types of brick scutches.

They are the " Stock and Blade " scutch and the solid scutch. Briefly, the difference is that in the former the stock and the blade are not permanently fixed, whilst in the latter the blade and stock—or head and shaft—are securely fastened.

Stock and blade scutches are used in the South of England, the solid type being more favoured in the provinces. A scutch does not have a hammer-head and must only be used for cutting a brick whilst held in the hand or upon a cutting bench. In effect the stock and blade scutch consists of a steel blade and a wooden stock. These steel blades are usually 9 inches long when new and, after use and re-sharpening, they may be reduced to a least useful length of 6 inches, when they should be discarded. A maximum width of 1¼ inches is usual for the blade, which may be either flat-chisel edged or pointed as a punch. The modern type of stock consists of a metal eye welded to a metal shank which is covered on opposite sides by two pieces of beechwood semicircular in section, thus forming the handle. This is an advance upon the older type which consisted of one piece of wood the eye of which being naturally weak was strengthened with a metal band. To give the necessary pitch to the blade the inside faces at the top and bottom of the eye are bevelled. Hardwood wedges are used to temporarily secure the blade to the stock and the action of cutting tends to tighten—rather than to slacken—the blade whilst it is in use.

There is not much difference between the solid scutch and the brick-hammer except, of course, that there is no actual hammer-head worked on to the solid steel. It consists of a solid steel head with two pointed or chisel

ends and an eye which has been drifted through to receive the shaft.

N.B.—In the other pattern the eye was in the shaft—not in the head.

The scutch is a cutting tool, and for soft bricks the stock and blade is the most practicable tool to use, whereas for hard bricks the heavier solid type is the most efficacious.

The Lump-hammer

Another hammer used by the bricklayer is the "lump" or "club" hammer which is almost identical with the mason's lump-hammer and, indeed, it is used in much the same manner. Actually it is considerably shorter than a mason's hammer and consequently much lighter in weight. Also it has a wider face. It is a rectangular solid block of steel of symmetrical pattern having a central wooden shaft and is made in various weights ranging from 2½ lb. to 4 lb. A good average weight is one of 3 lb.

The Bolster

This tool is an outsize in chisels and is 4 inches along its cutting edge. It is a derivation of the ancient brick-axe, although it is similar in name and not unlike a mason's boaster." In its action it is rather different because the bolster is used to cut a brick with a splitting effect and the boaster is used to smooth the face of the stone.

However for small cuts the mason's boaster can be used as a nicking tool with advantage. Bolsters should always be used in conjunction with a lump-hammer and not as is sometimes done expediently with a brick-hammer.

The method of using this tool is illustrated on Plate XIV.

Other Chisels

A very useful tool is the chisel known as a "pitcher," and whilst it is employed in a manner somewhat similar to a bolster, it is rather quicker in action and, slightly, rougher in effect.

As the bolster has a cutting or shearing action so the pitcher has a bursting action. Similarly, the bolster—when properly used as indicated in the cutting of pieces of bricks on the lower half of Plate XIV—will leave a fairly plain or even surface to the cut portion, whereas a pitcher will always tend to leave a rough, broken surface with superfluous material on one piece of the brick and a hollow surface on the other.

Passing on to the cutting chisels we find that these are usually of two patterns—one is the straight type and the other is the "lewis" or "plugging" type. Both chisels are made from best quality tool steel bar, either of 1 inch or ¾ inch diameter, and of "round," "hexagonal" or "flat-round" section. Of the straight type there is not much to say except that it is made up in various lengths of from 10 inches to 2 feet with an ordinary chisel point drawn out by a blacksmith.

The other type of chisel has a flattened point with a cutting edge at opposite direction to the widening, and because of this it is sometimes called a cross-cut chisel. For straightforward work, as shown on Plate XIII, the straight chisel is the most adaptable, and for solid work—thick walls and concrete floors—the cross-cut tool is to be recommended.

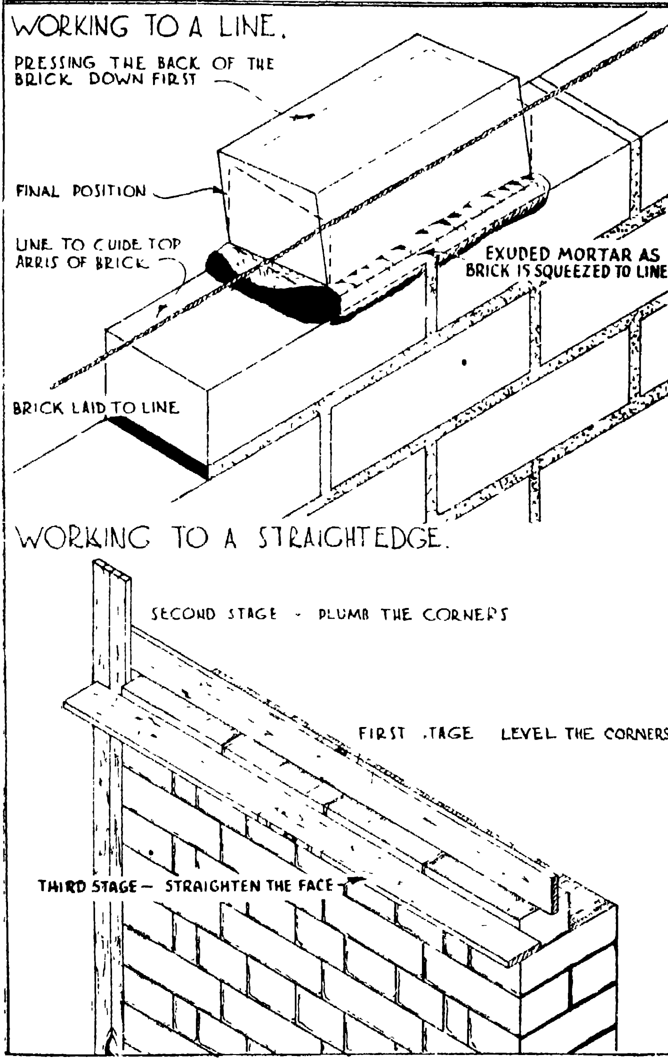
In the latter case the chisel has a tendency to bind when driven too far, and when struck sharply in a sideways direction it will not snap across as would be the case with the straight tool as the web provides extra lateral strength.

The Plumb-rule

As an aid to maintain perpendicularity the bricklayer again has the choice of two instruments, a plumb-rule or a plumb-level. In both cases the implements are made of wood, and whilst in the former the guide is a leaden weight, in the latter it is a spirit tube.

A plumb-rule consists of a piece of well-seasoned hardwood or yellow pine, 4 inches wide, ⅝ inch thick, and may vary in length from 4 feet to 5 feet according to individual

PLATE VI. SETTING THE BRICKS



choice. It has an egg-shaped hole, suitable in size to receive a lead weight, or "bob," which is usually 3 lb. in weight, and saw-cuts at the opposite end to secure the line from which the bob is suspended. Down the centre of the board, or "rule" as it is called, a line is scribed which is parallel to both edges. This means that both edges of the rule must be equidistant for the whole of its length.

When the rule is held upright (as shown on Plate IX) and the bob swings into the egg-shaped hole, the plumb-line should be coincident with scribed line on the rule, and then the plumb-rule is truly vertical or "plumb."

The other piece of apparatus is not so complicated; it comprises a perfectly straight piece of wood similar in size—though often somewhat shorter—to that specified for the plumb-rule, and a small 2½-inch spirit tube. At one end of the rule, and about 4 inches from either extremity, is an eyehole. This is a circular hole, and in its base it exposes the bubble of the spirit tube. When correctly set the tube should register the true horizontal, and as the tube is made perpendicular to the working edge of the plumb-level or straight-edge, then the edge of the appliance will be perfectly vertical. Two simple laws are involved with the application of these tools—the first, that is the plumb-rule, works upon the force of gravity, and the second, that is the plumb-level, works upon the action of a liquid finding its own level.

Thus it will be seen that the erection of brickwork is an applied science.

Bricklayer's Line and Pins

This is a simple contrivance and is illustrated on Plates VII and VIII. In effect, it is a light line made from hemp or cotton suspended horizontally between two steel pins.

There appears no end to the duplication of the bricklayer's tools, and line-pins are no exception.

To secure the line to the wall a steel pin is needed and there are two patterns of steel pins. First there is the popular round-headed type, and secondly there is the

more uncommon anchor-headed type. A length of 100 feet of line is ample for ordinary use and three-quarters of it should be wrapped evenly upon the shank of one pin and the remainder on the shank of the other pin. By doing this only one end of the line will wear out during use.

Otherwise if the line is wrapped equally on to each pin the middle part of it will become worn out by cutting it with the trowel, by friction and by rotting with lime.

Bricklayer's Tingle

Another component of the bricklayer's tool-kit is the tingle, which consists of a metal plate about 5 inches long and $2\frac{1}{2}$ inches wide, both ends of which are furcated so as to hold the line to a level position.

A simple and equally efficacious method is to use a 3-inch loop of line There are many other tools that are needed by a bricklayer in the course of his work, such as rules, squares, bevel-stocks, adaptations of trowels, and so on. The loop of bricklayer's line instanced above is to be regarded as an alternative method and not as an expedient (*see* lower half of Plate VIII).

CHAPTER III

THE PRACTICAL APPROACH TO BRICKLAYING

HAVING dealt with the materials used by the bricklayer and also explained the tools with which he is equipped, it now remains to learn how the one is to be applied to the other, so that he may learn to build.

Picking Up Mortar

Before attempting to lay a brick one must learn how to pick up a trowelful of mortar. This will prove most difficult of achievement. To obtain proficiency in this subject a great deal of practice is essential. For it is only by actually going through the motions that the wrist will become supple, the stabilising degree of balance be sensed, the correct hold of the trowel developed, and the strength of the grip required to hold the mortar on to the trowel be ascertained.

As has already been stated, the blade of the trowel—which is made in sizes of from 10 inches to 13 inches long—is unbalanced owing to the widening and thickening of the right shoulder. This eccentricity is of definite advantage when picking up mortar from a board.

To pick up mortar follow these instructions: Place the mortar centrally, in a heap, on the mortar-board, and stand close to the board so that the toes of your boots are almost touching it. Then grasp the trowel firmly by placing the tip of the thumb over the ferrule and allowing the remaining part of the thumb to rest partly upon the side of the handle. The remaining fingers should be placed around the handle of the trowel with the first finger of the hand underneath the ferrule and tight up against the shank. This arrangement of the hand is productive of the proper grip. When this action is properly mastered it will be found that complete control of the trowel is obtained.

Mortar cannot be taken up or held on to the trowel if the grip is not made as described above.

Hold the trowel firmly, with the arm almost fully extended in front of the body. Now make a downward stroke slightly towards the body, inclining it to the left with the back of the trowel. Then, by a turn of the wrist and with the face of the trowel, make another stroke from the point of commencement of the first stroke so as to form a wedge of mortar. The angle so formed by the two cuts should be exactly the same shape as the blade of the trowel.

Test this by placing the trowel flat on the top of the two cuts and notice how the "vee" coincides with the shape of the blade.

To become expert at this process, which will take a considerable time, practise picking up the wedge-shaped piece of mortar on to the trowel. This is done by slightly turning the wrist toward the left with a slightly scooping movement, and at the same time lowering the hand. The action of dropping the wrist in this fashion means that the point of the trowel is raised, whilst it remains in the mortar heap, and that the greatest portion of the mortar will lie at the base of the trowel.

If the hand is kept level with the blade, then the point of the trowel will remain in the mortar and can only be removed therefrom by the exertion of a tremendous strain. Should the handle be raised above the point of the trowel—as it is pressed into the mortar—the trowel will have a downward inclination and its point will have a tendency to penetrate into the mortar-board.

Careful consideration of the elementary points is of utmost importance, otherwise the learner is apt to strain or injure his wrist.

Spreading the Mortar

When this operation has been thoroughly mastered, the next action to be learned is how to "spread the mortar." Spreading mortar consists of placing the mortar evenly

and of equal thickness in the appropriate position for the subsequent laying of the bricks.

To do this correctly pick up a trowelful of mortar and lift it until it is about level with the elbow. Then, with a downward and backward movement of the arm, swing the trowel and at the same time give it a half-turn with the wrist. By turning the wrist the trowel blade will be changed from a horizontal position to a vertical one and the mortar will begin to slide from the trowel. Whilst it is falling the mortar will be guided by the downward and backward sweep of the arm into its ultimate position. It must, however, be emphasised that this action is not easy; in fact, most bricklayers say that " judging the bed " is the art of bricklaying.

Carefully practise spreading the mortar until a roll of mortar about 3 inches in diameter and at least 1 foot 6 inches long can be made in an unbroken line. By quickening the action the thickness of the mortar roll may be reduced and its length increased until a point is reached when the cohesion of the mortar breaks down.

Obviously, bricks cannot be laid on a roll of mortar because it would be impossible to flatten 2 inches or 3 inches of mortar with a 7-lb. brick. Easy compressibility is obtained by the simple expedient of making a " vee "-shaped indent in the roll of mortar previously laid. It is this " furrowing " of the mortar that spreads it out evenly so as to form a bed for the bricks which are subsequently laid upon it. By drawing the hand towards the body, with an undulating movement of the wrist, the pressure on the trowel can be alternately exerted and released and a wavy surface is formed to the mortar.

Practise this, and when you have perfected the movement you will have successfully accomplished half of the practical aspect of bricklaying--that is, in the manual sense.

Most readers will be wondering when the correct method of laying a brick will be described, but progress can only be made by short steps. They are necessarily difficult ones, therefore the sequence is correspondingly slow.

There are two other methods by which mortar may be taken from a mortar-board, and they are described as follows.

The first method is to cut away—with the trowel held vertically—that portion of the mortar at the bottom of the heap, and then, holding the trowel horizontally, slide it along the board until it reaches the previous cut. All that remains is to steadily raise the trowel and by keeping it horizontal the mortar will remain upon it.

The second method is to cut the edge of the mortar as before, but keeping the trowel in a vertical position. By moving the hand towards the body and at the same time keeping the edge of the trowel blade sliding along the mortar-board a portion of mortar is separated from the remainder in the heap.

Of the three methods of bricklaying as practised in this country the "pushing" method is the most popular. The two remaining methods are known respectively as the "larrying" method and the "grouting" method.

At the present stage we shall consider the more usual way of setting or laying bricks—namely the "pushing" method. Englishmen excel at this method, whereas Continental and American bricklayers favour the "grouting" system.

The Pushing Method of Bricklaying

The "pushing" method is perhaps the most difficult manner of placing a brick in a recumbent position. Recumbent it must be for it must rest easy upon its bed.

Having spread the mortar in the desired position on the wall, keep hold of the trowel in the right hand and grasp a brick in the left hand as in the manner previously described. Now lift the brick and let it rest very gently on the bed of "spread" mortar, first pressing the back of the brick down slightly in advance of the front. This is shown on Plate VI.

So far as the first course of bricks to be run is concerned the foregoing is not very important, but it is of considerable importance in the setting of the subsequent courses.

A good bricklayer keeps his work clean and, naturally, keeps himself clean. To do this, all the surplus mortar that exudes from between the bricks during the setting must be taken up by the trowel and not allowed to drop on to the ground or upon the toes of the boots. Therefore, the back edge of the brick coming down first, and as the weight is being transferred towards the front of the brick, the mortar is squeezed out towards the front. This surplus mortar will be sufficient to make the next cross-joint, and it must be removed with a smooth sweeping action so as to avoid staining the face of the brickwork.

Although each movement has been dealt with as a separate and distinct action, it should be understood that all the movements, when properly combined, should be executed with a definite rhythm. Correct bricklaying demands a skill that can only be developed by a considerable amount of continuous practice.

Why is it necessary to press down the back of the brick first? Well, here is the reason. When the brick is placed into position it should be laid to a line, which is stretched from corner to corner of a wall, to serve as a guide. It is to this line that the top arris of every brick in each course must be set so that by this means the true building line as well as the level of the courses and the verticality of the wall are maintained (*see* Plate VII).

Having placed the back edge of the brick down first a forward pressure is exerted by the hand to bring the top front arris of the brick to the line, after having seen that its bottom arris is approximately over the top arrises of the bricks in the course immediately below (*see* Plate VI). Perfection in building means that the bricks must be laid in the vertical plane or, as the bricklayer terms it, " plumb." Also the bricks must be laid so that their cross-joints, or ends, are in a broken vertical line from top to bottom of the wall. This is called " keeping the perpends."

Building a Short Length of Brickwork

For short lengths of brickwork, say under 4 feet 6 inches,

a line is not needed to keep the brickwork straight, but the bricks are laid or " run " to a " straight-edge " (*see* lower sketch Plate VI). But in every case the corners, or ends, are built first so that this initial work may be used as a guide to the building of each separate wall.

These corners are built laying some bricks in a row and several of these rows are built until the " corner " or " lead " is raised. Each successive course is reduced by " half-a-brick " as it progresses upwards. This is amply illustrated on Plate VII.

Every row of bricks, or course, as it is more properly called, should be tested for the gauge in order to preserve the correct level as previously described in Chapter I. Throughout the entire length of each part of the courses comprising the corner, perfect horizontality is obtained by applying a straight-edge and testing by a spirit-level. Some straight-edges have a spirit-tube permanently set in their upper working edge and where this is not the case, a hand spirit-level must be applied to check the level of the work.

Not only must each and every course be kept level, but each external angle must be kept plumb and the extension of the bricks ranged correctly, with a straight-edge, to the opposite corner.

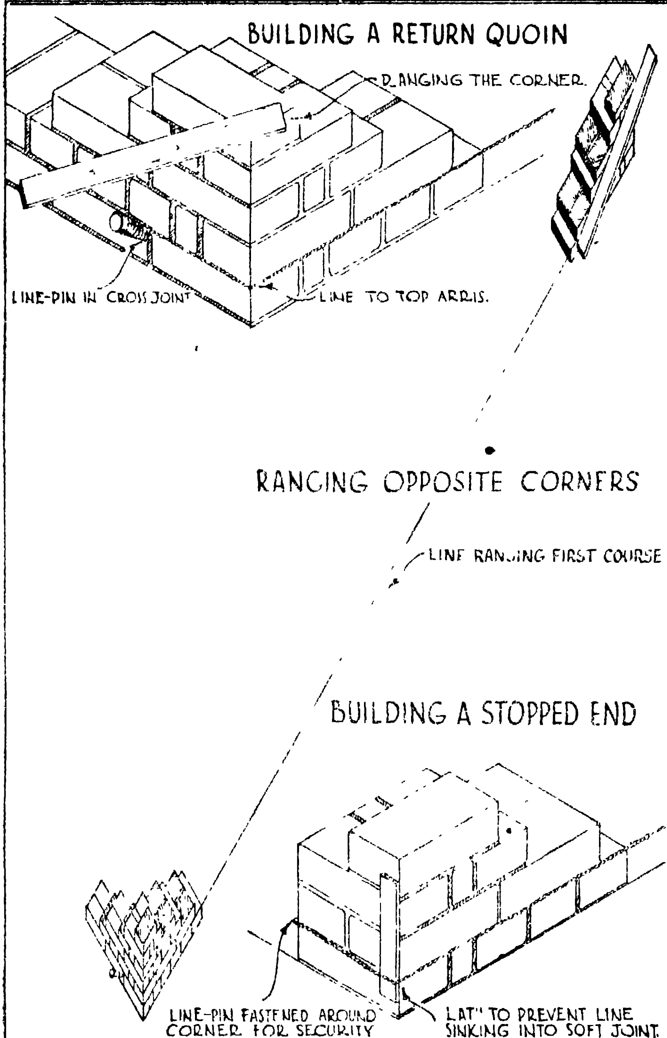
Return Quoin

When two walls meet so as to form two sides of a square the angle so formed is termed a " return quoin," but when the wall simply terminates and does not return or thicken out it is called a " stopped end " (*see* Plate VII).

Stopped End

To build a stopped-end corner the first procedure is to place a brick in its proper position at the limit of the extremity as shown on the plan. Also it must be placed in its proper direction with regard to its heading or stretching faces according to the nature of the bond of the first course to be laid in the wall.

PLATE VII. BUILDING WORKING LEADS



If the first course of a 9-inch wall is to be laid upon proper brick footings, then the first brick of the stopped end should be a header and next to it a queen closer, then continuing with more headers until the course has been extended sufficiently. This extending of the first course is called "drawing out" the corner. In the case of a $4\frac{1}{2}$-inch wall the first course would commence and carry on with a series of stretchers. Continue with subsequent courses, taking care that the brick which has been placed upon the corner is not moved backwards—as it is very apt to do if care is not taken to avoid this movement. To prevent this movement place a brick (dry) on its edge and hard up against the first bricks and this slipping movement will be avoided.

Ranging a Corner

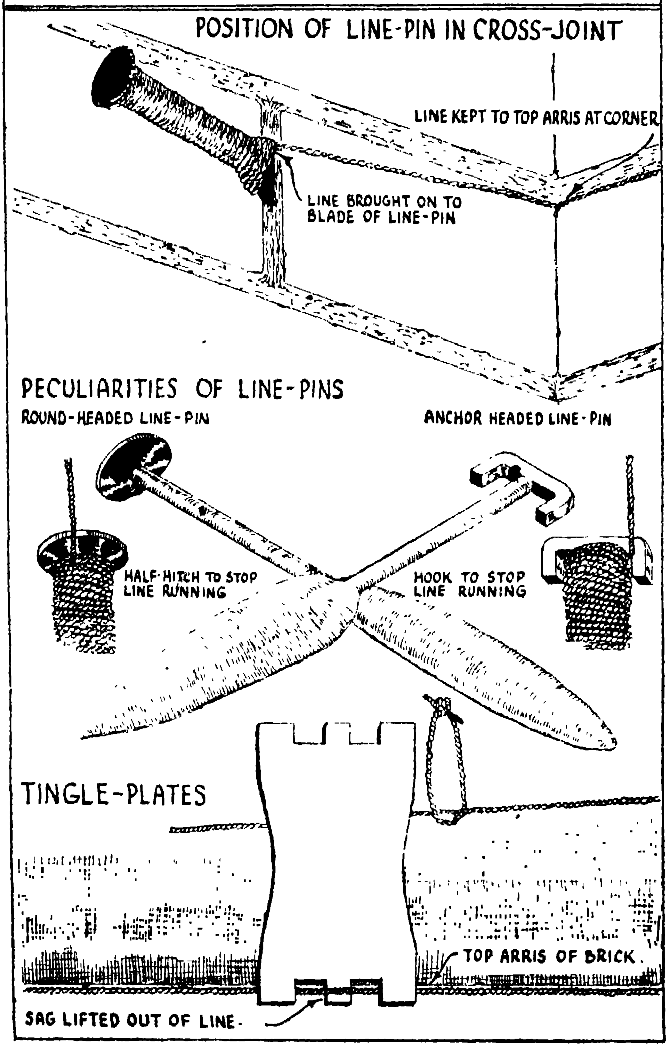
As well as levelling the bricks in each course as the corner is built up, it is necessary to range the bricks to the face of the wall by means of a line which is stretched from the newly built corner to the previously built one. Fastening the line to a newly built corner is a tricky business, especially when the bricks are saturated with moisture. However, it may be accomplished by making two or three turns of the line around a brick very close to one end, and placing the brick on its edge with the line touching the face of the newly built (or green) work. Should the pull, which is required to make the line taut, be too great for the brick-on-edge, then it may be prevented from moving by placing a couple more bricks in front of it.

Whilst the line is in position bring the bricks into correct alignment by tapping them into position with the shoulder of the trowel. This lining up only refers to the first course. All subsequent courses are ranged by means of the straight-edge.

Importance of Good Eyesight

Good eyesight is essential to good bricklaying. For instance, when building a corner the repose of the first

PLATE VIII. LINE AND LINE-PINS



brick determines the ultimate condition of the corner. If it should be out of level so as to "run down" towards the corner, then the heading face will, inevitably, be overhanging; contrariwise, if it is "running-up," then the heading face is battering.

Make certain that this first corner brick is both level and plumb. Having done this, be careful to look down the face of the following corner bricks and ensure, by a keen employment of the eyes, that they are placed in the same continuous vertical plane. This is vital during the first three courses, and no less necessary when building the other courses on the corner.

Plumbing a Corner

Bear in mind that you cannot discern the level of the bricks on the corner whilst you are looking down upon them; to see how the bricks are "running" it is important to come away from the corner and to stand facing the work, and, if necessary, stoop down to the exact level of the work. Having seen that every corner brick has been laid so that the faces are flush, or coincident, hold the plumb-rule in one hand so that it is in an almost vertical position. Now place the rule with its narrow edge towards the corner at about 1 inch from the actual angle (*see* Plate IX).

When the plumb-rule is held against the brickwork the plumb-bob or lead weight should swing into the hole in the plumb-rule: if it does not, then the bricks must be knocked into their correct position with the brick-hammer.

The Plumb-rule

For the true perpendicularity of his work, the bricklayer relies upon the infallibility of the plumb-rule.

That the wall is battering will be indicated by the bob hanging on the side of the hole nearest to the wall, and the plumb-line will be on that side of the scored line which is in the centre of the plumb-rule. On the other hand, if the work is overhanging the bob will not swing in the

hole and it will hang towards the outside edge of the rule, the plumb-line being between the centre line and the outside edge of the rule.

When the work is overhanging there is a strong tendency for the bob to pull the rule out of the hand of the operator. It is good practice to hold the toe of the right boot against the bottom of the rule when building face work, otherwise there is a tendency to build a slightly overhanging corner. More difficult is the plumbing of a corner when working over-hand, and it is an advantage to place a nail, or small piece of slate, into the bed-joint upon which to rest one corner of the plumb-rule.

Overhanging Work

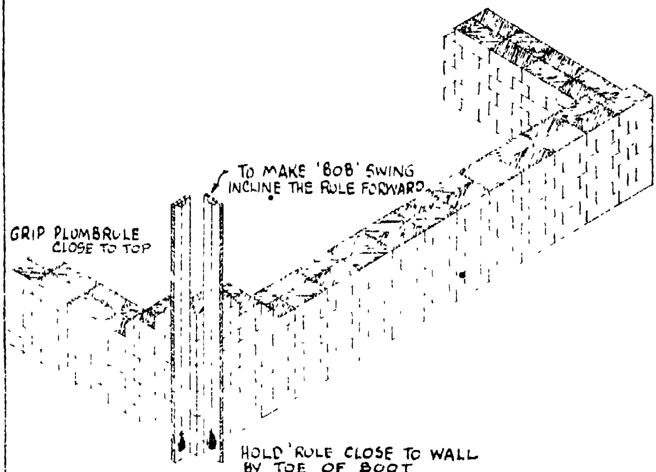
By far the easiest mistake to make is to build the work so that it appears as if the top courses are falling over. A wall in this condition is said to be "overhanging." Not so prevalent is the mistake of building the work so that it appears to be falling backwards: this is called "battering."

Many reasons have been advanced for the tendency of newly built brickwork to overhang. A sound one is that as the plumb-bob draws its cord towards the centre of the earth it forms a normal to the earth's surface and a radial from the centre of the earth. By taking this statement to its logical conclusion, it would appear that a wall should be wider at the top than at the base.

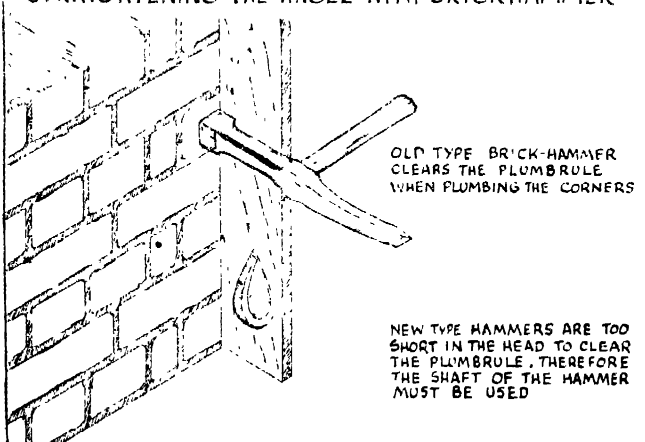
Examine this reasoning carefully and you will see that it does not really explain the propensity to build a wall in an overhanging manner. Perhaps the more reasonable deduction is that as a brick has varying degrees of density, and as it must rest upon a plastic or semi-fluid bed of mortar, then it develops a proclivity to slide to the face of the wall. With blue bricks, or ordinary common bricks which have been saturated with rain-water so that they have no power of absorption, or suction as bricklayers call it, there is a tendency for the bricks to float outwards and never inwards.

PLATE IX. PLUMBING THE CORNERS

POSITION OF PLUMBRULE WHEN PLUMBING CORNERS



STRAIGHTENING THE ANGLE WITH BRICK-HAMMER



However, what is most important is the overcoming of this difficulty because prevention is better than cure.

At the outset it was stated that when setting bricks it was insisted upon that the bottom edges of the bricks are made to coincide with the upper edges of the bricks in the course immediately below. The only possible way to see this is carried out is to stand over the wall and look down the face of the work and obtain the correct alignment by knocking the bricks into position with a brick-hammer. If, after having carried out this procedure, the bricks situated at the corner are still overhanging when tested by applying the plumb-rule, then they must be inclined inwards. This will make them batter-in themselves, and as they float they will gradually assume a truly perpendicular position.

Fundamentals of Bricklaying

In bricklaying there are two major objects: (1) to keep the work plumb and (2) to keep the work level. And when these principles have been mastered the learners are on the high-road to becoming successful bricklayers.

If success is to be achieved several attempts at building a corner will be necessary as it is a difficult process. Here we may recall the moral of the story of "Bruce and the Spider."

Having overcome the major difficulty of "building a corner," or return quoin, the building of that piece of walling between the two opposite ends is the next operation.

Building the Wall

This particular job is known as "running the line" because all the intervening bricks should be laid with their top arrises coincident with the bricklayer's line which is stretched from corner to corner. Remember also that the bottom arris of each brick must be in line with, or in the same face as, the top arris of the bricks in the course immediately below. This point has already been con-

sidered, but it is here recapitulated for emphasis (*see* upper diagram Plate VI).

When dealing with the building of a corner, return quoin or stopped end, it was stated that the opposing bricks were ranged to a line which was temporarily stretched from corner to corner. In a short space of time the corner bricks will have become set and as long as ordinary care is exercised they will not be easily disturbed.

Bricklayer's Line and Pins

Let us now consider the next part of the bricklayer's equipment. We shall need, namely, a line and a pair of line-pins. The line which is used by most bricklayers is sometimes called a chalk-line and is made of hemp or cotton. A line 100 feet in length is sufficient for ordinary work.

When in use the line should be wrapped for three-quarters of its length on one pin and the remainder of the line on the other pin. By doing this only one end will wear out at a time. Otherwise if the line is wrapped equally on each pin the middle portion of the line becomes worn-out by friction and rotting by the lime of the mortar. Also the lines will be cut by careless control of the trowel.

Before using a new line bricklayers take the stretch out of it by suspending it in long loops over high beams and attaching a weight to the ends of line which are looped just clear of the ground. Then when the distance of the weight above the floor becomes stabilised the line will neither stretch nor shrink any further unless it is saturated with water.

So much for the line; now let us examine the line-pins. A line-pin is made of forged steel and has a spear-shaped blade, a cylindrical shaft and a washer- or anchor-head.

The spear-shaped blade may be from $2\frac{1}{2}$ inches to 3 inches long, and 1 inch broad in its widest part, and $\frac{1}{8}$-inch thick in its centre (*see* Plate VIII). It is this blade which, when placed into the cross-joint between the bricks, holds

the line in its correct position at the corner of the wall. The circular shaft is for winding the line upon, and this reeling must be done with a certain amount of care otherwise the line will bulk up in the middle, appear as if it were a ball of string, and slip off the pin when least expected.

The best line-pins are forged from one piece of steel, cheaper ones are made from cast-iron and are not to be recommended.

Steel pins are liable to rust very easily and it is sound advice to coat their shafts with bitumen or some other rust preventive, or wrap a narrow piece of paper around the shaft to prevent this action occurring.

If the foregoing precaution is not taken the rust will cause the line to iron-mould and rot.

There is always a tendency for the line to slip from off the end of the pin, and to prevent this happening the shaft is terminated in a button or, less frequently, an anchor-head. Button washer heads are easiest for handling when forcing the line-pin into a joint that has set; also they are a better target to hit with a hammer than the narrow anchor-head, but should the blade inadvertently fall out of the joint, when it is soft, then the line will become unwound as the pin descends to the floor.

Anchor-headed pins are difficult and awkward to drive in mortar joints although they possess the great advantage of being easily caught up by the line as it unwinds, whereas with washer-heads the line becomes completely unwound.

Of course, this unwinding from round-headed pins may be prevented by making a clove hitch upon the remainder of the line which is reeled upon the shaft of the pin.

Keeping the line to its proper position is a difficult job, and to ensure that this is done it is advisable to wind three or four turns of the line around the blade and close to the shaft. Wrapping the line around the blade of the pin will provide a broad surface which will allow the line to be firmly fixed to the top arris of the brick which is to be used as a guide.

Operating the Line

Operationally there should be a man at each corner. When the line has been "run through" each man is able to grasp the line-pin which has been fixed at his corner. The left-hand corner man should take out his pin at the same time as the right-hand man. He should then place the blade of his pin into the next higher course, selecting a suitable cross-joint. Having, in the meantime, kept the line fairly taut, the right-hand man will then take the sag out of it with his left hand and place the pin into its appropriate joint with his right hand.

"Putting the line up" is a difficult job when working single-handed, especially when the length exceeds 15 feet and the brickwork is very wet. Do not forget that this condition is fairly common in bricklaying.

It is not always possible to ensure that the work can be kept dry, or the bricks stored in a dry place, so that they must be used in a saturated condition, thereby increasing the difficulty of keeping the work plumb and level.

Use of the Tingle

To stretch the line perfectly taut and to maintain the tension required is a very difficult operation. The process of pulling it too tight will tend to set up too much strain and the line will easily break, therefore it is necessary to take a gentle but firm pull.

Any "sag" or deflection should be removed by passing the line through a tingle-plate. Bricklayers usually make their own tingle-plates and the layman can make a substitute out of a piece of line formed in the shape of a loop.

CHAPTER IV

FURTHER METHODS OF PRACTICAL BRICKLAYING

Peculiarities of Bonding

A KNOWLEDGE of the peculiarities of each special type of bond may be learned by placing a number of bricks "dry," that is, without mortar, into their correct position. This should be done before any serious attempt at building a wall, and a first-hand acquaintance of the principles of bonding will thus be acquired.

The various types of bond and the methods of constructing brick walls are fully illustrated and explained in the volume on Constructional Details in this series.

Trying Out the Bond

Always try out the bricks in any new length of walling; a good bricklayer always does this: otherwise you may probably have to take up the bricks that you have already laid. Thereby you will eventually save both mortar and time.

Of course, it will be realised that the examples of brick-bonding as shown in most text-books appear to work perfectly, as they are intended, but when they are applied to a particular piece of walling, something appears to have gone amiss. In such cases you must apply the principles of bonding and not the given examples to your job.

Often enough the length of walling does not work out to an even brick and, in such cases, a half-brick or piece of brick is needed to fill the gap.

Pieces of a Brick

"Bat" is the name given to the piece of a brick. There is, for instance, a quarter-bat or closer, the half-bat and the threequarter-bat, each having a $2\frac{1}{4}$-inch, $4\frac{1}{2}$-inch and $6\frac{3}{4}$-inch face respectively.

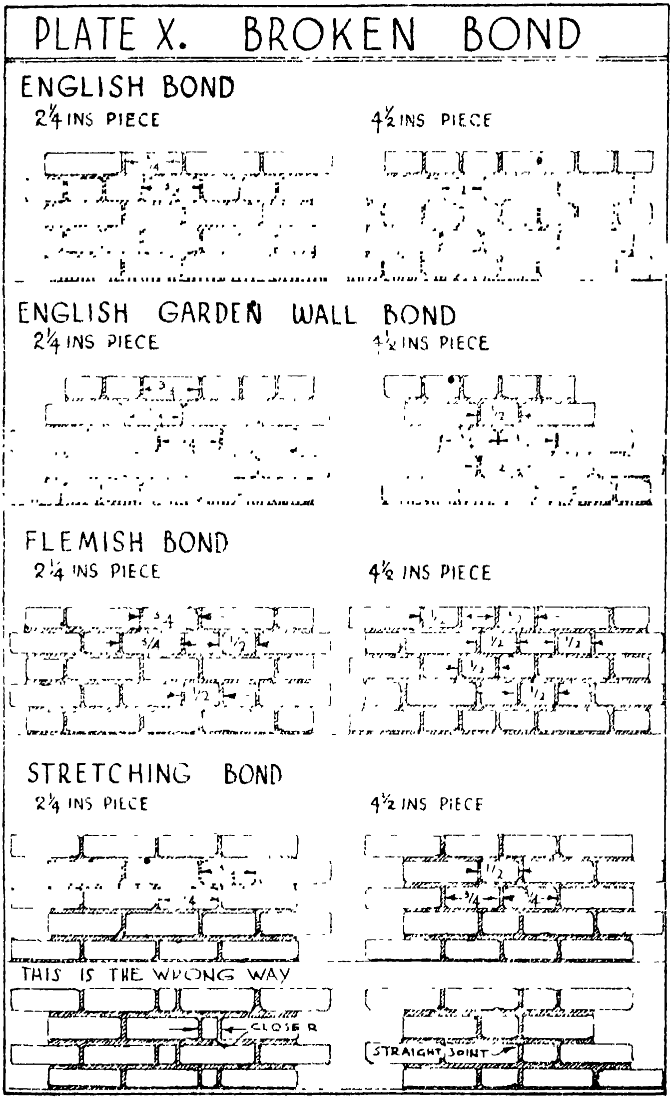


PLATE X. BROKEN BOND
ENGLISH BOND
2¼ INS PIECE
4½ INS PIECE
ENGLISH GARDEN WALL BOND
2¼ INS PIECE
4½ INS PIECE
FLEMISH BOND
2¼ INS PIECE
4½ INS PIECE
STRETCHING BOND
2¼ INS PIECE
4½ INS PIECE
THIS IS THE WRONG WAY
CLOSER
STRAIGHT JOINT

Broken Bond

In English Bond, a threequarter-bat is used in the heading course and a half-bat and a threequarter-bat in the stretching course when after the bricks have been "run" from each end there remains a $2\frac{1}{4}$-inch space (*see* Plate X).

When there is a $4\frac{1}{2}$-inch space remaining between the bricks in the stretching course of the wall, a half-bat is required to fill the gap. Remember that these pieces will only be suitable for walls built in English Bond—i.e. one complete course of headers followed by a complete course of stretchers.

A very unorthodox way of overcoming this difficulty is to work the half-brick space gradually out of the wall by "changing the bond" on the quoin. In this way the piece may be lost altogether although the corners will be "turned out" in the wrong bond.

Many and varied are "the tricks of the trade" in the bricklaying craft and some of the best-known are connected with the artifice of losing the piece. Obviously, it will not be possible to deal with all these devices in this book. Two will now be dealt with.

Having worked out the bond with some bricks in a dry state, to prove that there is broken bond in the wall, ascertain if it will be nearest in size to a three-quarter, a half or a closer. Then run the heading course through the wall from one end to the other and not from both ends to the middle.

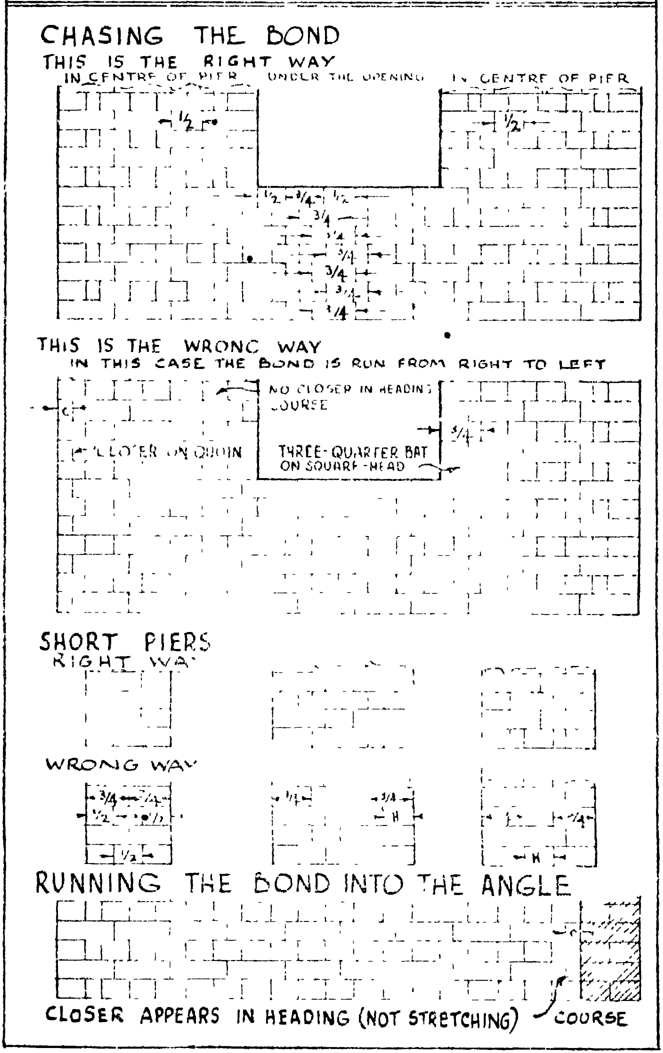
Stretchers are next run towards the internal angle of the wall—where the bond must be changed and then kept permanently in this position all the way up the wall.

Should both ends of the wall be external angles or return quoins, then it will be wrong to "chase" the bond to the angle. In this case it must be kept in the centre of the wall or placed under an opening and not kept in a position where it will appear as a fixture in the pier (*see* Plate XI).

Making the Bond

Making the bond necessitates the cutting and alteration

PLATE XI. BROKEN BOND



of the bricks. This is not as easy as it may seem. A bricklayer cuts a brick—never breaks it as the unacquainted are apt to say.

Cutting a Brick

To cut a brick the following tools are needed: (1) a lump-hammer; (2) a bolster; (3) a brick-hammer and (4) a scutch. Never, at any time, should a trowel be used to cut a brick as it is a very careless and haphazard way of doing the job.

A trowel is not used for this job by a good craftsman, obviously then it should not be attempted by the learner.

Cutting a brick by means of a lump-hammer and bolster is not, to the beginner, an easy task and, like the operation of spreading the mortar, needs a considerable amount of practice before the necessary degree of skill is attained.

By far the easiest portion of a brick to cut from a whole brick is a half-bat, and when you are able to cut two halves out of one brick you have reached a definite stage of advancement in the bricklaying craft.

Cutting a "closer" is the next step forward. Cut a whole brick into two halves and mark a line down the centre of the heading face of one piece. By this method, the half-brick will have been divided into two equal parts, each part being approximately $4\frac{1}{2}$ inches by 3 inches by $2\frac{1}{4}$ inches. Each of these closers will have three original arrises and one cut arris showing on its face.

Use of the Lump-hammer and Bolster

To cut a three-quarter bat, mark it and cut it so that the closer (the off-cut) is usable. Now cut the brick to the proper dimensions of a three-quarter and place it solidly upon a firm support, such as the ground or a plank which may be conveniently covered by a sack to form a better bed. Grasp the bolster in the left hand and the lump-hammer in the right, and then apply the edge of the bolster to the line that has been previously marked upon the narrowest face of the brick and give it a sharp tap with

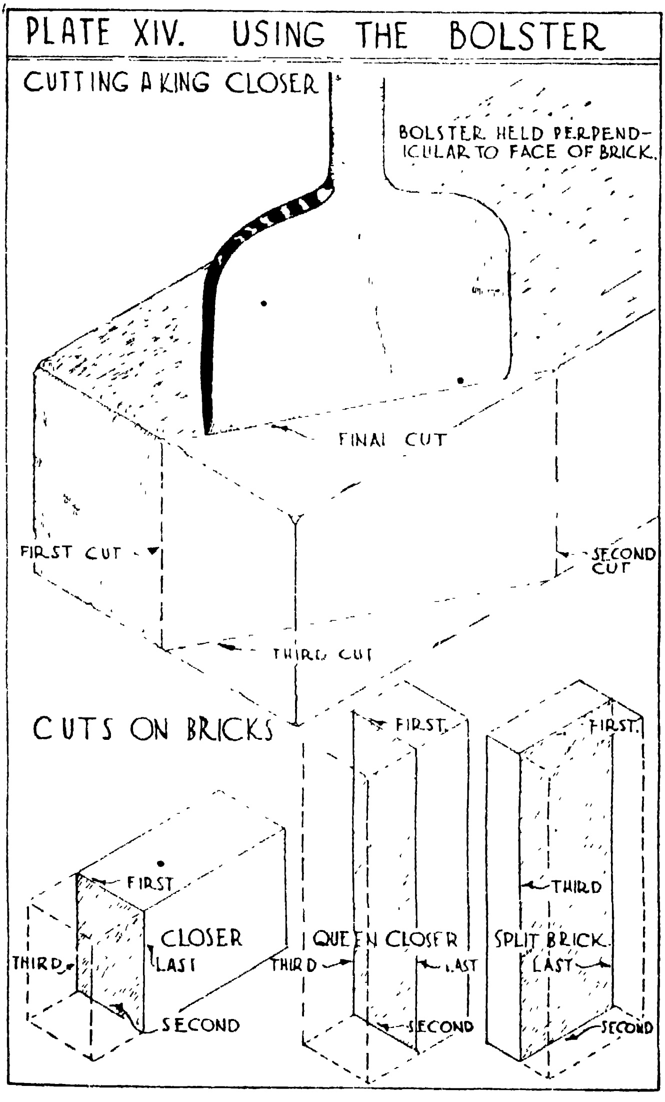


PLATE XIV. USING THE BOLSTER
CUTTING A KING CLOSER
BOLSTER HELD PERPENDICULAR TO FACE OF BRICK.
FINAL CUT
FIRST CUT
SECOND CUT
THIRD CUT
CUTS ON BRICKS
FIRST
THIRD
CLOSER
LAST
SECOND
FIRST.
QUEEN CLOSER
THIRD
LAST
SECOND
FIRST.
THIRD
SPLIT BRICK.
LAST
SECOND

the lump-hammer. Now reverse the brick so that the opposite face is uppermost, proceed as before and then continue the operation on the broader faces (beds). Do not try to cut the bricks from one face only—keep turning the brick round and do not cut the broad side first. The position and manner in which the bolster is held will influence the kind of cut that will result. For instance, if the bolster is inclined away from the cut, then the fracture will not be clean and straight—it will incline outwards leaving a lump in the middle which is called "a belly" by bricklayers (*see* Plate XV). This lump is difficult to remove, especially by means of a lump-hammer and chisel. Consequently it must be cut away with either a brick-hammer or a brick-scutch. To carry out this operation it is best to hold the bolster almost perpendicular but slightly inclining it inwards towards the face of the brick, and then give it a sharp blow with a lump-hammer. The resulting cut portions should present slightly hollow surfaces which should fit without recourse to further trimming. I must emphasise that this is a difficult operation and one that can only be mastered by practice.

Each cutting line that has been marked upon the brick should be cut or "nicked" by a light blow upon the bolster. Change the face of the brick every time that a blow is struck; do not hit the chisel more than once without moving it (*see* Plate XIV).

Cutting Glazed Bricks

Should the learner progress to such a degree as may be reckoned expert, then it is advisable for him to try his skill at cutting and laying glazed, or enamelled bricks. These bricks are extremely difficult to cut owing to the character of the brick and the adhesion, or lack of it, of the glaze to the body of the brick. It will be found that with some of these bricks there is a tendency for the glaze to chip away and fly off the face in flakes. However, this fault may be prevented by placing a piece of thick paper between the chisel and the hammer. This procedure will

take some of the vibration out of the bolster and reduce the likelihood of shattering the glaze before the effect of the blow is taken up and absorbed by the body of the brick.

Use of Brick-hammer and Brick-scutch

None of the tools that a bricklayer uses for cutting bricks are easy to master, and the brick-hammer and the brick-scutch are perhaps the most awkward of them all. A brick-hammer is, obviously, a dangerous and difficult tool to use. Therefore, the learner must be very careful that his control of the hammer is efficient and that he uses it in a correct manner, otherwise he may easily cause himself a serious personal injury.

There is usually a long head on the brick-hammer and this makes the balancing of it an awkward job. Bear this in mind and control its downward swing by a very firm grip.

The cutting edge of the hammer is not more than 1 inch wide and this, combined with its weight which is about 3 lb. (varying according to the pattern), tends to produce an acute concentrated cutting impact. By holding the brick firmly upon the left leg, just above the knee-cap, so that the shock of the impact is taken up by the femur, a fairly comfortable and comparatively safe position may be found in which to cut the brick.

Some of the impact of the hammer blow may be taken up by placing the left hand in such a manner that, whilst gripping the brick firmly, it lies between the brick and the leg. Undoubtedly this is the best way to hold a brick whilst cutting it with a brick-hammer.

There are several other ways of carrying out this operation, but they are not to be recommended. One is to hold the brick in the left hand with the left arm fully extended in front of the body and, whilst the brick is thus held, strike it a full blow with the brick-hammer. An expert craftsman is able to make all the ordinary cuts in this manner.

It must, however, be borne in mind that the blow from a brick-hammer is a vicious one ; and if, inadvertently,

the hand or leg is hit, the memory of it will remain for a long time. However, when held properly upon the leg, the brick can be cut to an amazing degree of accuracy ; but when it is held in the hand with the arm in an extended position, there is little or no resistance to the blow. As a result the cut will be limited both in its scope and application. Until a certain amount of skill has been developed, it will be observed that a sufficiently penetrative blow cannot be made. As a result of the weak and more or less ineffective blow, a bad cut is made as previously described when explaining the process of cutting bricks with the lump-hammer and bolster, and the resulting hard core of material must be removed by applying the chisel-end of the brick-hammer.

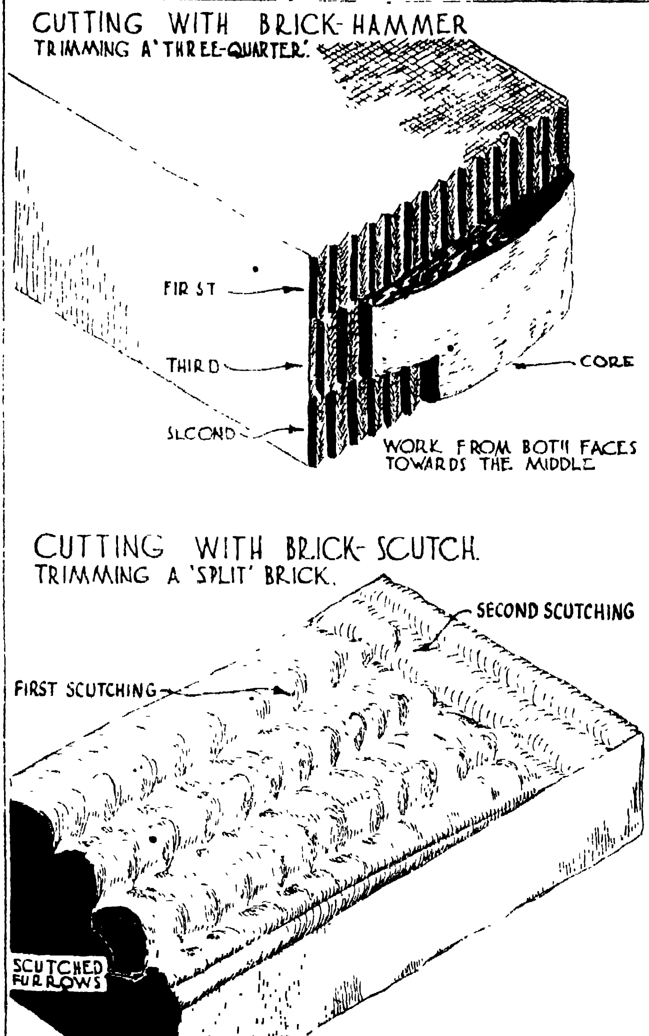
The cut edge of the brick will now be rough and jagged, so it is smoothed and straightened by using the hammer-ended face of the brick-hammer.

Whilst we are dealing with brick-cutting, let us now consider the best manner in which to remove the surplus material from the fractured surface of the brick by means of the brick-hammer and the brick-scutch—or scotch as it was originally called. It is very sound practice when cutting a brick to ensure that the blow is always driven towards the thickest part of the brick and never towards the feather-edged or thinnest part, so that the greatest resistance is offered to the blow. Otherwise, the thin edge will crack away and the brick will be spoiled. In such cases it will be necessary to get another brick and start the process all over again.

To attempt to cut out the rough lump of surplus material by aiming at the brick in a haphazard fashion is a waste of time and effort. The correct action must be carried out systematically by bringing down the brick-hammer on to the brick at the outside edge of the rough portion and each blow will remove about ¼ inch of the core at a time.

Repeat these blows until the cuts are carried through to the other side of the superfluous material, at the same time keeping them parallel to the side of the brick.

PLATE XV. CUTTING OUT THE CORE



This process of removing surplus material from the brick is somewhat simplified by using a scutch instead of a brick-hammer in a similar manner to that already described when using a brick-hammer.

The scutch, which is lighter in weight than the brick-hammer and possesses a chisel-edge at one end and a point at the other end, needs less resistance to the blow; therefore, it is possible to cut smaller pieces of brick with a scutch than with a brick-hammer.

Blows that have been struck with the pointed end of the scutch will produce furrows resembling those made on a piece of stone by a mason using a mallet and pointed chisel. And a succession of these blows, when made in a straight line, will cause the surface to appear as a series of rough furrows down the surface of the brick (*see* Plate XV). If these furrows are about 1 inch apart the ridges can be somewhat easily removed by commencing other furrows.

So much for cutting the bricks before they are laid: we will now consider cutting them when they are in the wall.

Cutting Out Old Work

To tie new walls to old walls, the old work must be cut away to receive the new work, and this operation is known as "cutting out the bond." Joining, or tying, old and new walls together may be accomplished by a variety of methods, such as "Toothing," "Indenting," "Continuous Chasing," "Artificial Ties," and so on.

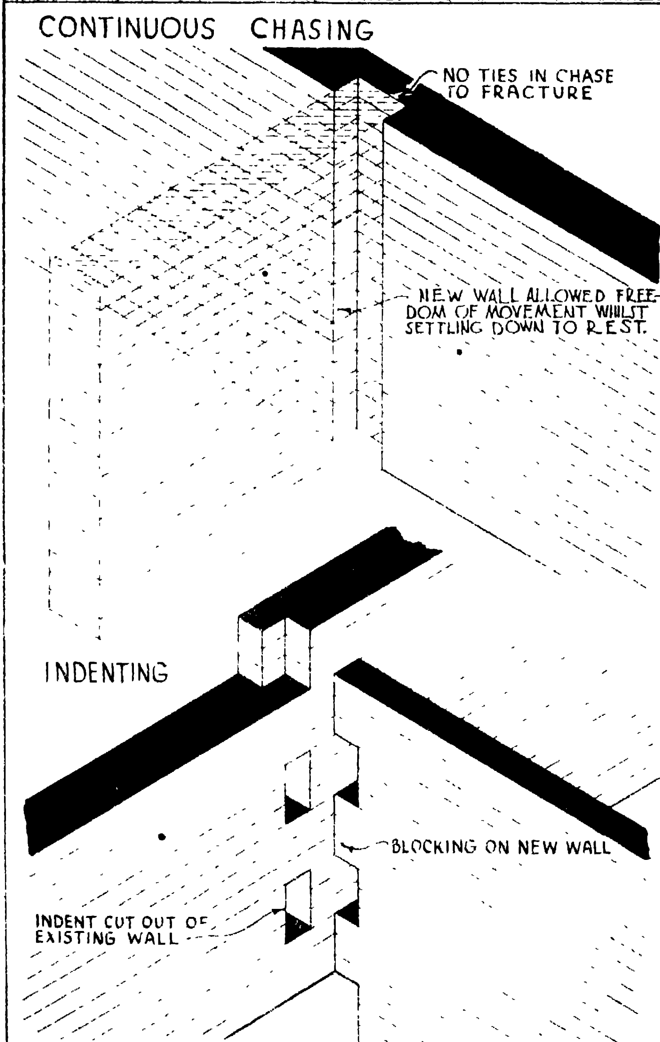
Continuous Chase

Possibly the simplest method and presumably the strongest—constructionally—is that known as the continuous-chase system.

To cut a continuous chase, mark the position of the junction of the new work upon the old wall, and having marked on the width of the chase, draw a plumb-line, representing both faces of the new wall, upon the existing wall.

If the new wall is to be $4\frac{1}{2}$ inches or 9 inches thick, the width of the chase should equal the full thickness of the

PLATE XII. JOINING NEW WORK TO OLD



wall, but if the new wall is to be 14 inches thick, or even 18 inches thick, then the chase need only be cut out to receive the middle 4½ inches or 9 inches as the case may be.

Supposing we take a 9-inch wall for an example, as this is a fairly common case. Having marked the face line for the new work, and also set off about 9½ inches to provide a clearance for the new 9-inch wall, we must "plumb up" these marks and make a chalk line (*see* Plate XIII).

Next, look for a convenient cross-joint in a stretching course at a height of between 3 feet 6 inches and 4 feet 6 inches.

With a lump-hammer and a 1-inch chisel, proceed to cut out the mortar from the cross-joint as deep as is possible without binding the chisel and at the same time freeing as much mortar as possible. Now, hold the chisel about an inch from the joint and commence to cut the brickwork and continue until the brick is cracked through. Make sure that the chisel is held square on to the face of the brick, otherwise the resulting fracture will run back to the cross-joint and only a small triangular-shaped piece of brick will be removed instead of a parallel and rectangular piece.

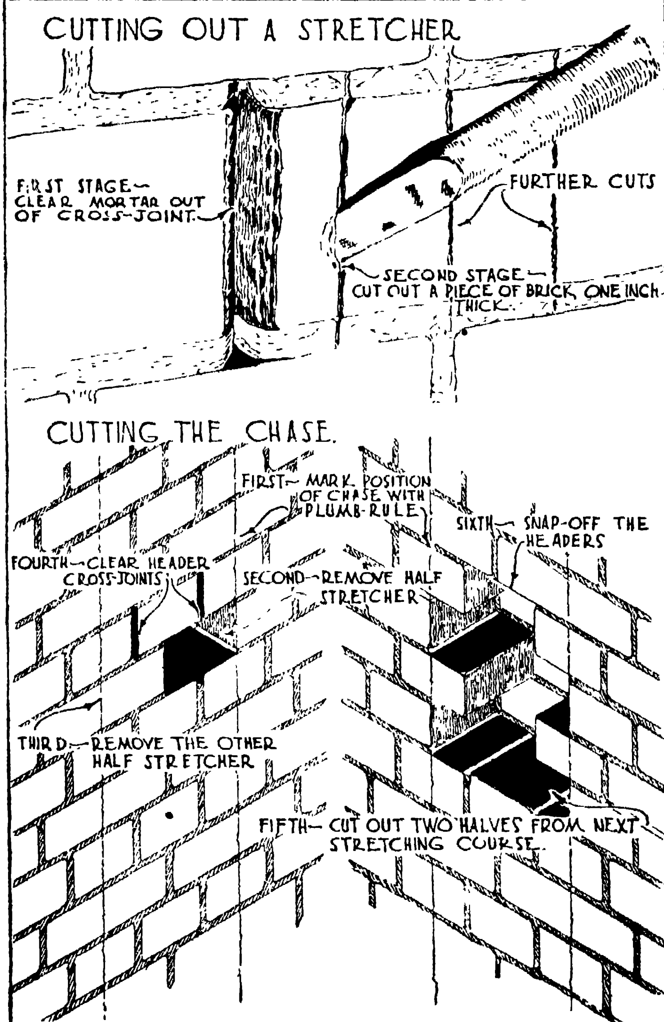
Continue with this cutting action, by trying to cut out a piece of brick about 1 inch wide by the height and depth of the brick every time. Do not try to smash or burst the brick, as it is best to do the job methodically.

When you have cleared the half-brick on the right-hand side of the cross-joint, nick with a chisel the other half on the left-hand side where it is cut by the chalked line. A few sharp blows and the remaining half-brick will fall out. Carry out this procedure with the course of bricks immediately above the header, then the 4½ inches of the bricks in the heading course will be left projecting, and these can easily be snapped off by a sharp downward blow with a lump-hammer.

Having thus established an opening, the remaining portion may be cut with a fair amount of ease.

The foregoing remarks apply equally to the cutting-out for toothing, or for indenting.

PLATE XIII. CUTTING OUT BRICKWORK



Putlog holes for the supporting of scaffolding are also cut in the same way—that is, to clear the cross-joint first, and then cut away a piece of brick about an inch wide at a time (*see* Plate XVIII).

For wall ties, it is only necessary to cut to the width of the chase and 4½ inches deep into the existing wall.

When a new wall is connected to an old by means of a chase (*see* Plate XII), any subsequent settlement will not cause the wall to become fractured because it will be able to move up and down freely and yet remain securely fastened to the existing wall.

In building the brickwork to fit into the chase, there is no necessity to take into consideration the gauge of the brickwork of the old wall.

Indenting

Indenting means cutting out holes in the old wall, three or five courses deep, to receive projecting portions of the new work having a similar depth (*see* Plate XII)

Toothing

Toothing means that every other course must be cut out so that the new work interlocks course by course with the old work. The last two cases, i.e. indenting and toothing, are the strongest forms of binding old and new walls together ; but the first, chasing, is the easiest to build and is safe enough providing there is no unusual settlement or lateral spread of the newly built brickwork.

CHAPTER V

CHARACTERISTICS OF BRICKS: THEIR PECULIARITIES AND USES

BRICKS are many and varied in their colour and texture and they are made from a diversity of raw materials, the most common being some form of clay. Clay bricks are made by hand, or by wire-cutting, or by pressing.

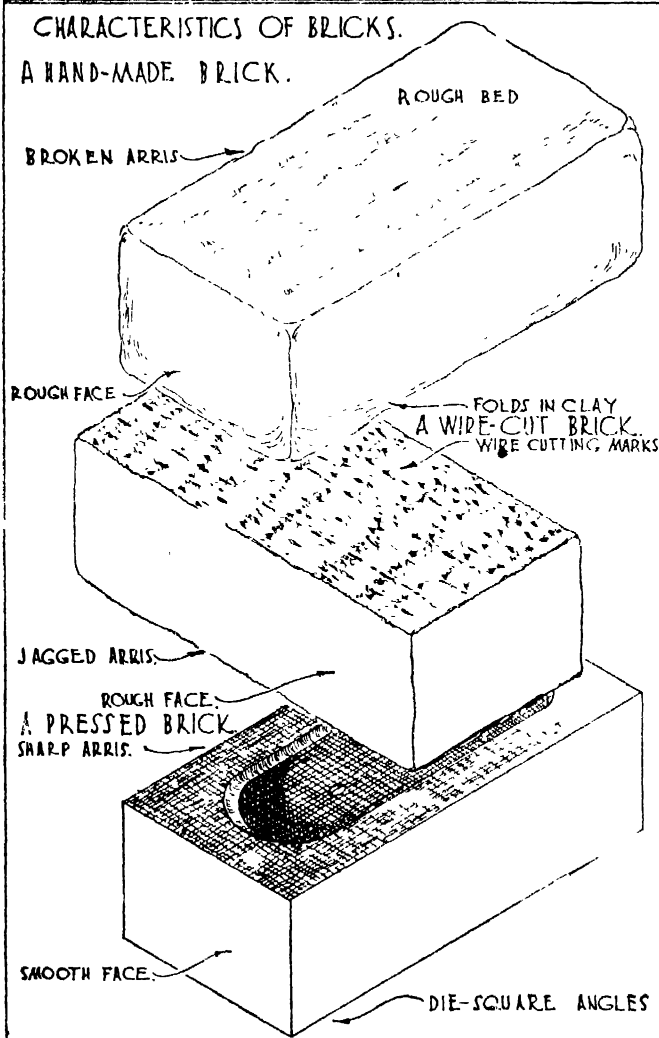
Hand-made Bricks

Hand-made bricks are usually made by "slop-moulding" or "sand-moulding," and the difference between the two methods is not apparent to the layman, although it is to the professional. In the former method, water is used to prevent the clay adhering to the sides of the brick-mould, whilst in the latter, sand is used for precisely the same purpose.

Expert knowledge, however, enables a trained bricklayer to tell at a glance if he sees grains of sand remaining on the face of the finished brick that it was a sand-moulded brick and is popularly termed a sand-faced brick. Obviously, therefore, a good bricklayer should be able to classify almost every kind of brick in common use in his locality as this knowledge is of great importance when repairs or alterations are about to be effected to existing work.

The difference in appearance between a water-struck and a sand-struck brick has already been described, and now it will be explained how it is possible to distinguish a hand-made from one that has been made by a machine. Perhaps one feature of hand-made bricks which shows above all others is the cracks that appear in the corners of the bricks. But they are not really cracks, they are folds which are caused by the clod of clay being placed into the mould in such a manner that the corners of the mould are filled last. Naturally it goes without saying that sand-faced, hand-made bricks are the best of all types of bricks. They have

PLATE XVI. TYPES OF COMMON BRICKS



a definite charm which cannot be imparted to machine-made bricks (*see* Plate XVI).

Machine-made Bricks

Despite efforts to hide the fact—and there are many—machine-made bricks never fail to produce a harsh mechanical effect.

For building warehouses, factories and railways this has been considered a desirable quality in the industrial sense, but the charm of hand-made bricks is that they may be employed to harmonise with any surroundings—especially with the green colours of trees or grass.

Wire-cut Bricks

More bricks are now produced by the wire-cut process of manufacture than by all the other methods combined, although the resultant bricks may not be the best of their type of goods.

Now follows an outline of the manufacture of a machine-made wire-cut brick. First of all we must consider the raw material; this is chiefly boulder clay or carbonaceous shale.

The former material does not produce such a good brick as the latter, although the raw material is ground to a very fine state. Fine grinding is necessary for boulder clay because it contains a large proportion of lime or magnesia in the form of nodules which must be reduced.

Most bricks are porous, and those made from boulder clay are no exception. Therefore, as the rain beats upon the face of the wall, it is absorbed into the body of the bricks and should a small piece of lime be close to the surface, it will also absorb the moisture. Because the lime has been burned at the same time as the brick, and because the lime will slake when in contact with water, the lime will expand and force the clay structure apart, thus blowing away large pieces of brick from off the face of the brick (*see* upper sketch Plate XVII).

By this means the faces of walls built with boulder clay bricks and in exposed positions are often severely pitted.

The obvious remedy for a wall of this nature is to render the whole face with cement and sand; but, of course, prevention is better than cure. Prevention is accomplished by running and washing the clay so that all the larger stones and pebbles detach themselves from the surrounding material and settle down to the bottom of the tanks. Those parts of the clay which are more flocculent than the others take a longer time to settle and, being colloidal, result in a material which has the consistency of butter.

The clay, when settled and partly dried, is now in a condition for feeding to the machines.

Although the clay has gone through all this preparation, it may still contain lime or magnesia in some form or other, and the presence of either of these constituents will definitely cause subsequent decay of the brick.

After having prepared the clay in the foregoing manner, it is fed into a "pug-mill" which forces it through a die that has been made slightly larger than the bed area of the brick.

The orifice or die through which the clay column is extruded is made proportionately larger than the finished (burnt) brick, according to the shrinkage percentage of the clay. For example, assume that the known shrinkage of the clay is 10%, the size of the die required to produce a brick measuring 9 inches by $4\frac{1}{2}$ inches on the bed would be 10 inches by 5 inches.

As the extruded column of clay is pushed out of the die, it is carried by rollers to a "cutting-off" table where it is cut by wires which are spaced a distance of 3 inches or so apart according to the required thickness. This severing of the column will produce as many as from 4 to 8 bricks at a time.

From the "cutting off" table the bricks are carried away on pallet-boards to the drying shed. Here they are set down upon the ends to dry for about a week until the water of manufacture is thoroughly dried out, and it is here that any soluble salts that may have been contained in the raw material are brought to the surface and deposited upon the brick as scum.

Afterwards, the bricks are "set" in a kiln, usually of the continuous type, and steadily burned for a period of three weeks, after which they are ready for the market.

Bricks that have been made from shale have followed a similar process except that when the shale is quarried or mined it appears to be like a rock and must be allowed to break down, or weather, during the winter months by being left exposed to the vagaries of the weather; or—as in a modern works—it may be pulverised and reduced to a plastic condition by grinding and soaking.

Pressed Bricks

Pressed bricks are generally made from shale which is kept, more or less, in a dry state, the homogeneity of the "green" (unburned) brick being provided by the extreme pressure exerted by the machine press. Each pressure may be as much as 200 tons on each brick.

An indication of the thoroughness to which brick manufacture is developed is instanced by a well-known Fletton brick which is pressed four times (*see* Plate XVII).

Defects in Bricks

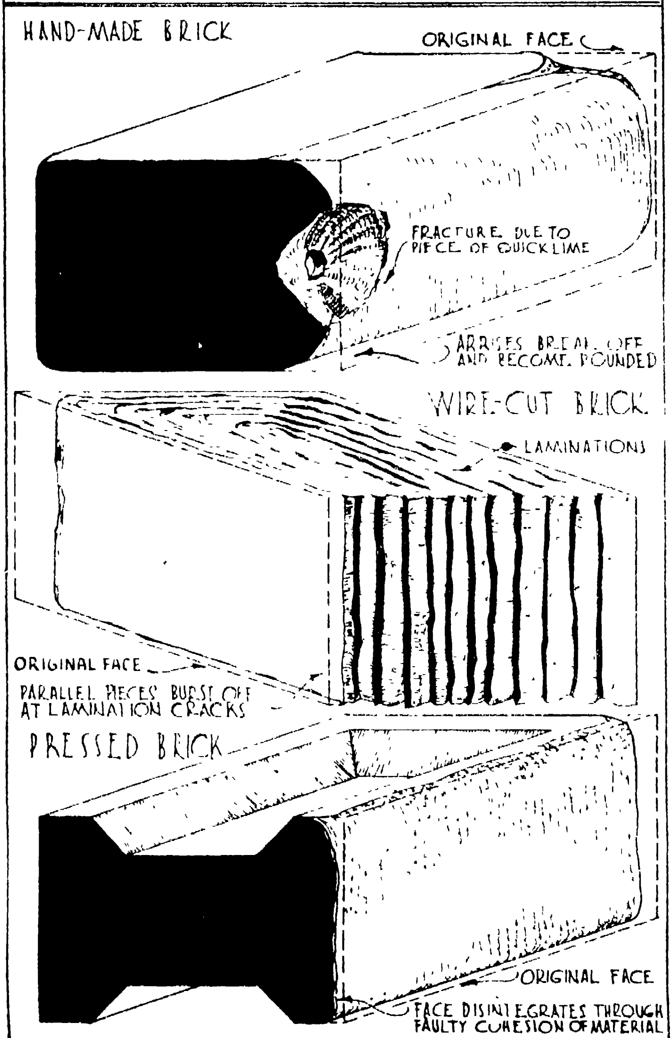
All bricks are liable to faults which are basically inherent in the raw material, or which are developed either during their manufacture or during the process of burning, or both.

For instance, as the making of hand-made sand-faced bricks is as near to perfect as possible, and as the product is well-nigh imperishable, there is no need to consider the repair of such brickwork.

Slop-moulded bricks are either burnt in continuous kilns or clamps where the resulting products cannot be effectively controlled. Such uncontrolled burning results in some of the bricks being under-burnt, soft, and yellow, whilst on the other hand, some are over-burnt, hard and small.

Soft yellow bricks disintegrate quickly when exposed to the atmosphere by powdering and crumbling away owing

PLATE XVII. DECAY OF BRICKS



to the lack of cohesion between the particles of material of which these bricks are composed. This type of brick is easy to cut out and it should always be replaced by one of a similar type and of a harder nature. Although it is advisable to choose a rather harder sample, care must be taken not to choose one that is too hard. More often than not, hard bricks are correspondingly brittle and apt to crack when being driven home.

Repairing the Brickwork

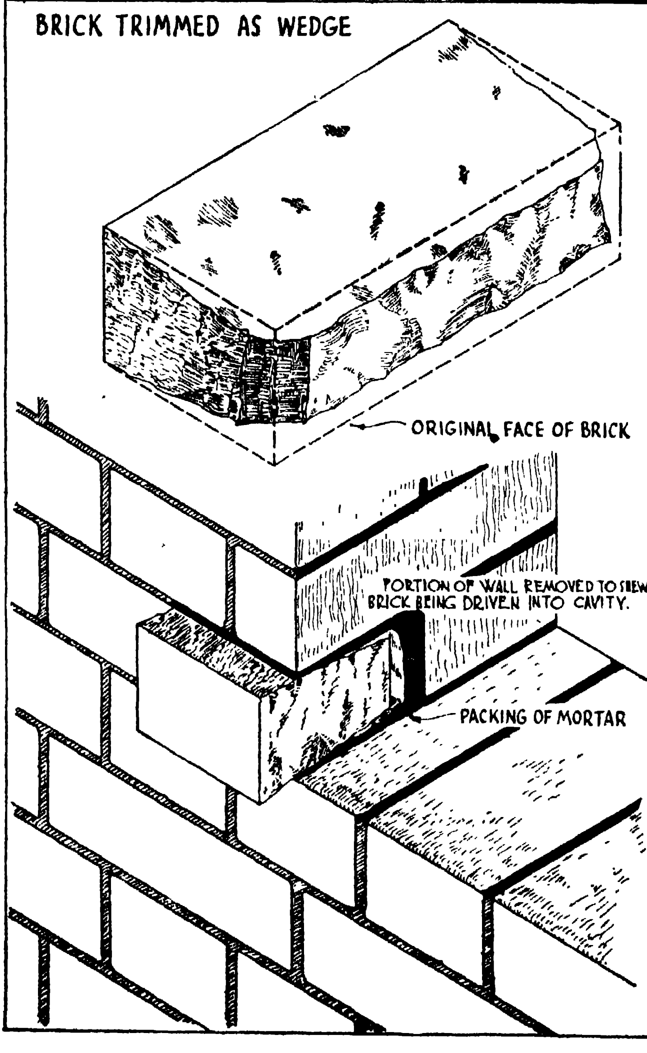
Faulty brickwork is repaired in the following manner. Cut away the decayed brick or bricks, clean out the hole thoroughly and do not allow any dust to remain in it. Then gently throw water on to the top and the sides of recess. It is unnecessary to wet the bottom of the hole as the water will splash on to it. The surrounding brickwork should also be well soaked with water.

Should it be a header that has crumbled away, then do exactly the same as for a stretcher, i.e., only cut it away to a depth of 4½ inches (*see* Plate XVIII).

Having prepared the hole, the next job is to fit the brick into it. So take a whole brick—or cut a half-brick as the case may be—and insert it in the hole. It should be an easy fit with plenty of room for a mortar joint all around it. Next, take the brick and pare some of it away from the bottom bed so that its cross-section would appear as the frustum of a wedge.

Cover the under surface of the top brick with mortar so as to form the top bed-joint. By doing this, some of the mortar will have dropped and collected upon the bottom surface of the recess. This must be used to spread upon the sides and bottom bed to form the cross-joints and the bed-joint, and is now ready to receive the brick. Hold the brick in the left hand, pick up some mortar on the trowel, then with the trowel in the right hand, cover all the brick with the exception of the face, with a coat of mortar. Now, hold the brick level and opposite to the hole, then drive it into the hole with the shaft of the brick-hammer. Greater power

PLATE XVIII. REPLACING A BRICK



may be exerted by applying to the brick a short piece of wood 4 inches by 3 inches and about a foot long which is driven "end on" by a lump-hammer; also, the brick is not so liable to fracture. Take great care to keep the brick level whilst it is being driven home. Do not allow it to dip down from back to front, otherwise it will be an extremely difficult job to straighten it again and the brick-face will not be flush with the wall.

As the brick is pushed home the surplus mortar will be squeezed out; this must be removed as it accumulates by cutting it away with the trowel.

This cutting away must be a continuous operation as the mortar will soon spread over the face of the surrounding brickwork and cause unsightly smears which will be very difficult to remove.

When the brick is finally driven home and it is in its proper position—having regard to its horizontal lines and vertical face—allow some of the mortar to project from the joint, and then, as the mortar begins to stiffen, press this surplus back in the joint by using the edge of the trowel. This "caulking" of the joint, so as to solidify it, will make the brick which has just been inserted absolutely immovable, and become an integral part of the wall.

Spalled Faces

It has been previously stated that it is practically impossible to completely eliminate the small pieces of free lime from boulder clay and that, when the bricks are burned in the kiln, the lime contained in the clay is changed into quicklime.

Should a piece of free lime happen to rest on or be near to the surface of a brick, it will expand when exposed to the rain and burst away or disintegrate the surrounding surface of the brick, and in many cases large pieces of brick may be spalled off (*see* upper sketch Plate XVII).

This disintegration of the bricks will produce a pock-marked appearance to the wall, and in such cases it is obviously a waste of time to cut out individual bricks as

all the bricks will be of the same character throughout the wall and therefore the face will be ragged and broken.

Perhaps the best way to repair damage of this nature would be to " hack out " all the joints and to render the wall with two coats of specially waterproofed cement mortar.

Lamination

One of the common defects due to the wire-cut method of manufacture of bricks is that known as lamination (*see* the centre brick Plate XVII).

Laminations are caused by faulty extrusion of the clay, and to the fact that the whorls, as made by the " auger " in the " pug-mill," do not cohere as they reform to make the clay column outside the die or mouthpiece of the extruding machine.

After the brick is made and is built into the wall, these layers still remain separated, forming partial capillary joints. Rain-water will penetrate into the imperfect joint between two laminations and when it freezes will expand and break off thin slabs of brick material, causing depressions on the face about a quarter of an inch deep and occurring along the full length of the brick. To remedy this defect the faulty brick or bricks must be cut out and replaced, as described above, for the soft yellow hand-made bricks.

Disintegration

Pressed bricks are good bricks and although they are somewhat harsh and mechanical, they very rarely develop defects. Some of the bricks of this type have a fair amount of crude oil or some other form of carbonaceous matter present in the new clay or shale. If this substance is not thoroughly burned out in the kiln during the firing process, it will cause the brick to disintegrate.

This is especially applicable when the brickwork is built below the ground level, therefore it is unwise to use these bricks (especially Flettons) for the foundations to walls unless they have been proved satisfactory in similar circumstances on a local job (*see* lower brick Plate XVII).

For ease in building, the novice will find that Fletton bricks, or any other type of pressed bricks, are to be recommended owing to the squareness and regularity of their shape.

"Wire-cuts" are considered to be the next best, and "hand-mades" the most difficult to build with, because they have neither square ends nor sharp arrises.

Sand-lime Bricks

Another perfectly easy brick to build with is one which has been pressed out from a mixture of sand and lime and steamed for a short while. Sand-lime bricks, as they are called, are to all intents and purposes, mortar bricks; and, as a rule, they are neatly pressed and are very regular and uniform in shape and size.

"The rate of absorption of moisture and the permeability of sand-lime bricks will vary according to the form of manufacture and the grading of the materials."

This condition makes them difficult to use on hot days owing to an excessive power of absorption, and on wet days they soon become saturated and will not remain in their true position as laid in the wall.

Because of this, it is not advisable to employ them in foundations or in damp situations.

As the brick surfaces ar clean and—usually—white, the wall surfaces do not require plastering or distempering when they are used for inside work, especially when they are used for larder walls, etc. The work should always be finished with a neat and narrow flush joint.

Making Concrete Bricks

A not very popular brick is the one which is made from concrete.

Sometimes it is used on industrial buildings and outhouses.

Though they are harsh and forbidding in appearance, they fulfil a useful purpose and can be made at home by persons having a very little experience of the building trade.

They may be produced in the following manner.

If the bricks are needed for outside work they should be composed of a hard, fine aggregate such as crushed granite, brick or stone. These materials should be crushed to a suitable size—say, the largest piece—to pass through a ring having a diameter of $\frac{3}{4}$ inch. Having obtained the hard material, place four bucketfuls of it on to a mixing stage similar to the one described for mixing mortar, and form a heap by emptying one bucketful on to the top of the other. Do exactly the same with two bucketfuls of sand and one bucketful of Portland cement, taking care to keep the materials in a conical shape (*see* Plate XIX).

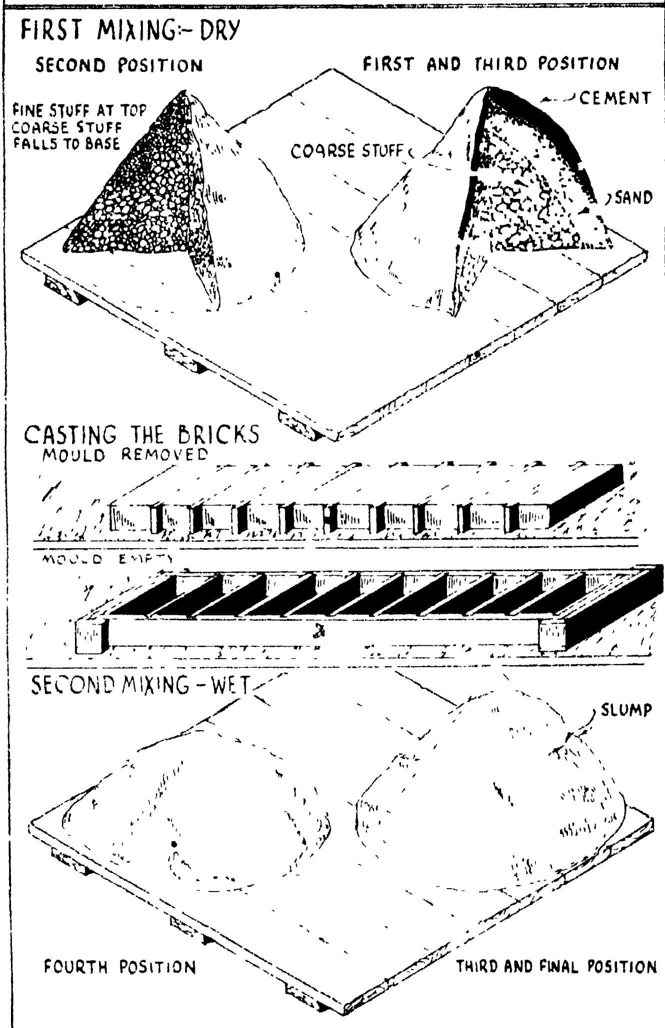
Then commence to mix the materials by driving the mixing spade under the materials and keeping it close to the mixing board, otherwise it will be very difficult to force the spade into the mass of materials as the mixture will be far too compact. Lift the dry materials up on to your spade and then allow them to slide away and fall into another heap about a couple of feet away by turning the blade into the vertical plane. As the three different ingredients fall down—say, from a height of 2 feet or 1 foot 6 inches—they will become intermixed. Then recommence the process at the opposite side. By means of this second turning the materials will have resumed their original position and they should now be thoroughly intermixed and ready for wetting.

For this purpose it is best to use a watering-can; although, if you are working single-handed, you will have to make a hole for the water in the centre of the heap in a manner similar to that described for mixing mortar.

After having wetted the mixture, it must be turned over in the same way as described for the dry mixing. Should the dry materials be insufficiently damped, then the work will be difficult and tedious; but if, on the other hand, too much water is added to the mixture, the tendency will be for the cement to be washed out of the mixture and it will run away, even if it tends to make the mixing an easier job.

It will also be found that the further the heap is dug into

PLATE XIX. MAKING CONCRETE BRICKS



the more difficult will become the turning over of the mixture. Loosening, by drawing out the compacted mass of partly wetted material, may be accomplished by means of a navvy-hack—better known as a pick-axe—before the process of shovelling may be continued.

Continue by turning the wet mixture over twice in exactly the same manner as when the materials were dry, and the resulting concrete will be gauged and ready to use.

This mixture must now be placed into previously prepared moulds to set and to form the bricks.

The mould may be a simply constructed affair if proceeded with in the following manner.

Make a box of a length sufficient to hold ten bricks and having nine equally spaced divisions of $\frac{1}{8}$-inch wood (*see* Plate XIX). The box should be made in such a way that it is possible to remove every portion of it without disturbing the newly made castings. This method of constructing the box means that it will not have a permanent or fixed base and that the ends must be made so that the individual pieces of wood will separate or come apart easily.

A box made in the manner just described will enable the making of the bricks to be continued until the whole of the gauging of concrete is completely used up.

When the bricks are required for inside work, a hard aggregate is unnecessary and coke-breeze or furnace ashes may be employed as the coarse material. Bricks made from this material are suitable for placing into any position where it may be necessary to fix timber. This is because nails may be driven into these bricks quite easily.

Concrete slabs are now used extensively for partitions. In size these slabs are from 9 inches by 6 inches by $1\frac{1}{2}$ inches to 18 inches by 9 inches by $2\frac{1}{2}$ inches, and it will be found that the process of making them is extremely difficult. They must be made on individual pallets and moulds, and my advice to the learner is not to try to make slabs of this type as they may be bought from any builder's merchant cheaper than he will be able to make them.

However, it is desirable that the layman should try his hand at making concrete bricks before building the wall.

There are many other kinds of bricks, but as they are manufactured for specific purposes, they remain outside the scope of this book.

CHAPTER VI

FINISHES TO JOINTS AND RE-POINTING BRICKWORK

Decay in Joints

PROBABLY the most common cause of decay in brickwork is that resulting from the existence of bad joints. Most builders build for profit and, in so doing, they stand to gain on that which they omit.

Mortar Deficient in Lime

They know, and so does the building inspector, that there should be a matrix of some kind in the mortar such as lime or Portland cement, if the mortar is to be capable of fulfilling its proper function.

If a builder should put less of the matrix into the mortar than is stipulated, then he will possibly make a greater profit than that originally anticipated, and the result will be a correspondingly poorer mortar and a weaker wall.

The occurrence of decayed mortar joints is not always attributable to poor mortar.

Influence of the Weather upon Mortar Joints

For instance, the wall may have been built during a period of frosty weather, or during a spell of very wet weather. It has been definitely ascertained that such bad weather plays havoc with the mortar joints. Not only will the mortar joints tend to burst, but the whole mass of walling may be thrust out of alignment by the effects of frost which may be considered to be one of the greatest natural enemies of builders.

The truth of this statement is proved by the fact that a mortarless form of wall construction has been devised whereby the erection of buildings may be carried on all the year round without stoppage, and weather con-

ditions will neither prevent nor influence interference with the continuity of the work.

The moral to be learned from this is do not build with mortar if there is any likelihood of frost.

To tackle the job of repairing mortar joints, some little experience of building processes, of bonds and of bricks will be needed. If you have read the foregoing chapters in their proper sequence you will by now have obtained some knowledge of these processes.

Hacking Out the Old Joints

Take the case of hård-pressed bricks. These are laid with very narrow joints between them, usually 3/16 inch wide.

On the other hand the rough, somewhat softer, hand-made bricks are laid with a thick joint, generally averaging $\frac{3}{8}$ inch between the bricks.

When the mortar in the joints becomes perished it may erode or become disintegrated to a depth of $\frac{3}{8}$ inch or more.

A depth of $\frac{3}{8}$ inch will not allow of a sufficient amount of mortar as will ensure the adhesion of the new mortar to the old. Therefore, in such cases, the recess must be deepened by hacking away the mortar with a scutch or a special tool; or it may be accomplished by cutting away the mortar with a lump-hammer and boaster.

By far the most difficult case of hacking out is that of pressed bricks with the narrow joints which have to be cut out; therefore, we will tackle this problem first. I have previously mentioned that pressed bricks are hard, and that hard bricks are brittle; therefore, great care must be exercised when cutting out the mortar between the bricks so as to preserve the arrises of the bricks—that is, if the quality of the work is to be maintained.

Hammer and Boaster Work

You must, therefore, proceed as follows :—

Obtain a mason's hammer-headed boaster—which is

about 2 inches wide—and whilst holding it in the centre of the joint give it a sharp blow with the hammer. Repeat this operation, only this time place the boaster as near as possible to the edge of the brick—for, by so doing, the mortar in the joint will be burst away to a depth of about ⅛ inch greater than the penetration of the chisel.

As the destroyed mortar in the joint is now friable it can be scraped out with the corner of the chisel; and then, if the mortar in the joint has not been cut away to what may be considered an effective depth, the foregoing procedure should be repeated. It will not be possible to make more than two cuts at the joints, because the boaster will tend to wedge itself in the joint and between the bricks and that will cause the bricks to snip at their arrises. Snipped bricks are spoiled bricks, so exercise strict care.

Surprise may be expressed at the mention of a mason's boaster and not a bricklayer's bolster—well, the reason is that the bricklayer's chisel is very thick at its cutting edge, whereas a mason's boaster is relatively thin. Furthermore, the bricklayer's bolster is too wide for cutting out a cross-joint.

Incidentally, when clearing or hacking out joints or pointing brickwork, it is desirable to commence with the cross-joints and then continue with the bed-joints.

Scutching and Picking

It has already been mentioned that wide or thick joints are easier to rake out than the narrow ones, and that they are usually cleared out by " scutching " or " picking."

To accomplish this, a bricklayer's scutch will be required and the best one to use has points at both ends.

A timber " dog "—one made of steel and not wrought iron—the ends of which have been specially tempered, is sometimes used for the purpose of hacking out the mortar joints. This tool can be recommended as being very good for the job. Commence by hacking out all the cross-joints in a patch of wall about 2 yards square and then do all the bed-joints in the same area.

Re-pointing the Joints

When hacking out and pointing, always begin at the top right-hand corner of the wall, working towards the left and downwards so that you are able to keep the newly finished work in a clean condition, and remove the scaffolding accordingly.

Having hacked out the joints, brush them vigorously with a very stiff bass-broom, and all particles of dust and loose chippings will be removed by moving the brush backwards and forwards and always parallel to the joints.

When the brushing process has been completed, moisten the whole of the face of the wall with clean water by using a partly worn flat brush for the purpose. See that the mortar inside the joint is moistened, and to accomplish this I would recommend that the stump of a well-used brush be used, rather than a new one with long bristles.

Next, obtain a hawk—or a hand-board, as it is sometimes called—which is a piece of $\frac{7}{8}$-inch board about 6 inches square and to which a piece of wood about 6 inches long—which forms the handle—has been centrally nailed and placed at right angles to the board (*see* Plate XX).

Upon the board place a small trowelful of mortar. When pointing a wall an ordinary laying trowel cannot be used, because it is too large; therefore, a special pointing trowel must be used.

These are stocked by all good tool merchants and usually available in lengths varying between $4\frac{1}{2}$ inches to 6 inches. Do not obtain one with a long blade, but rather a short one, preferably $4\frac{1}{2}$ inches in length.

A good craftsman rarely, if ever, buys a new pointing trowel; he prefers to use a worn-out laying trowel which has been cut down and ground to a reduced size. Another point to consider is that the blade of a ready-made pointing trowel is very thin and consequently has too much spring in it for the professional man. It is, of course, essential that the practical process of picking up mortar from a hand-board with the pointing trowel be persevered with in the

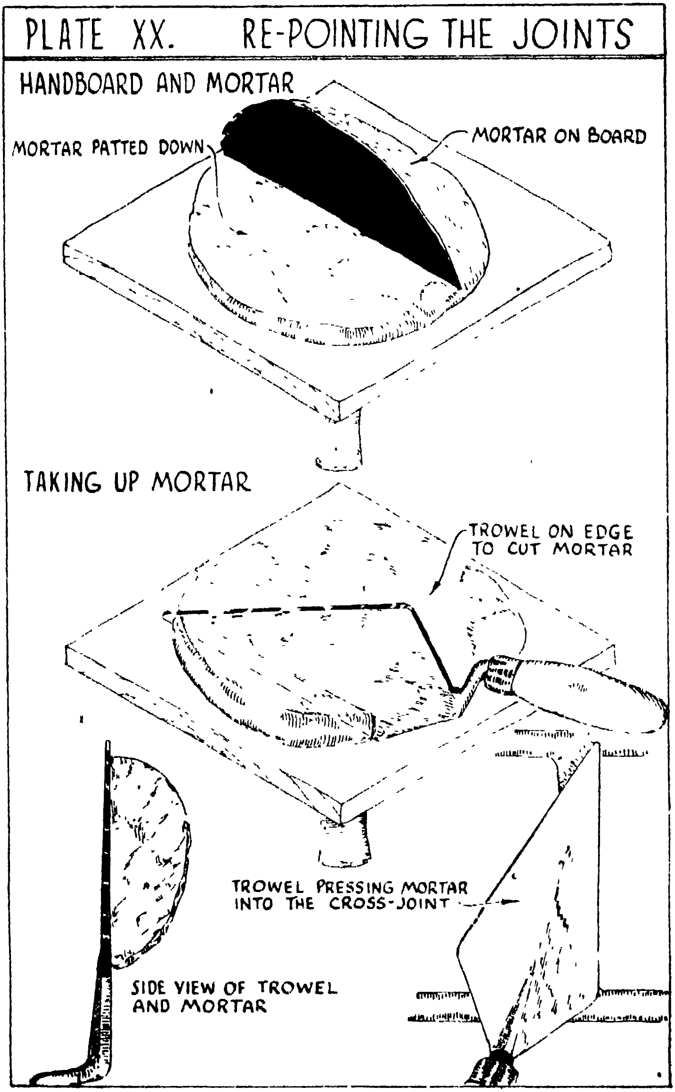


PLATE XX. RE-POINTING THE JOINTS
HANDBOARD AND MORTAR
MORTAR PATTED DOWN
MORTAR ON BOARD
TAKING UP MORTAR
TROWEL ON EDGE TO CUT MORTAR
TROWEL PRESSING MORTAR INTO THE CROSS-JOINT
SIDE VIEW OF TROWEL AND MORTAR

same way as with picking up the mortar from the mortar board.

To do this correctly, only a small amount of mortar must be placed upon the hand-board; just as much as can be conveniently held on a pointing trowel. Pat the mortar out flat on the board, then take the trowel and cut the mortar apart with it, using the edge of the blade for the purpose (*see* Plate XX). By a scraping movement, push the mortar outwards to the edge of the hand-board with a sweeping movement of the trowel and it will be found that when the trowel becomes clear of the board the mortar will be adhering to it.

Naturally, this process requires a certain amount of dexterity and entails continuous practice. Although this may be considered to be a difficult process, it is surprising what is capable of accomplishment by assiduous application to the task.

Having succeeded in getting the mortar to adhere to the back face of the blade of the trowel, place your hand in such a position that it brings the mortar deposited on the trowel parallel to and very close to the joint which is about to be filled. Then press the mortar firmly into the joint space by a twist of the wrist, and at the same time allow the trowel to rub along the sharp arris of the brick (*see* Plate XX). By this means you will find that you are able to deposit the mortar into the empty joint and the operation can be completed by pressing the mortar firmly home.

This is very important: Do not allow the mortar to stain the face of the wall. This is accomplished by keeping the mortar within the joint only and cutting it off neatly every time it is pressed into the joint.

Keep on pressing the mortar until all the spaces in the joint have been filled and then by holding the trowel in the opposite direction, draw it along the joint and at the same time compress the mortar firmly and evenly for a full arm's length in one operation. As this is done it will be noted that the joint mortar takes up a polish.

This process is known as ironing the joint.

There are many ways of finishing the mortar joints of brickwork.

Types of Joints

In the South of England a steel jointer is often used for the purpose of re-pointing instead of the usual pointing trowel. If, for instance, the ordinary square-edged pointer is used, the joint produced is known as a " tuck-joint." This type of joint is very good for outside work.

Another exceptionally good finish is the " bevelled " or " weather " joint, which is supposed to assist in shedding the rain-water and not retaining it, as is the case with some of the other joint finishings.

Of all the joint finishes the flush joint is probably the most effective as well as the most popular. Flush joints should be all that their name implies—full, smooth and flush with the face of the wall.

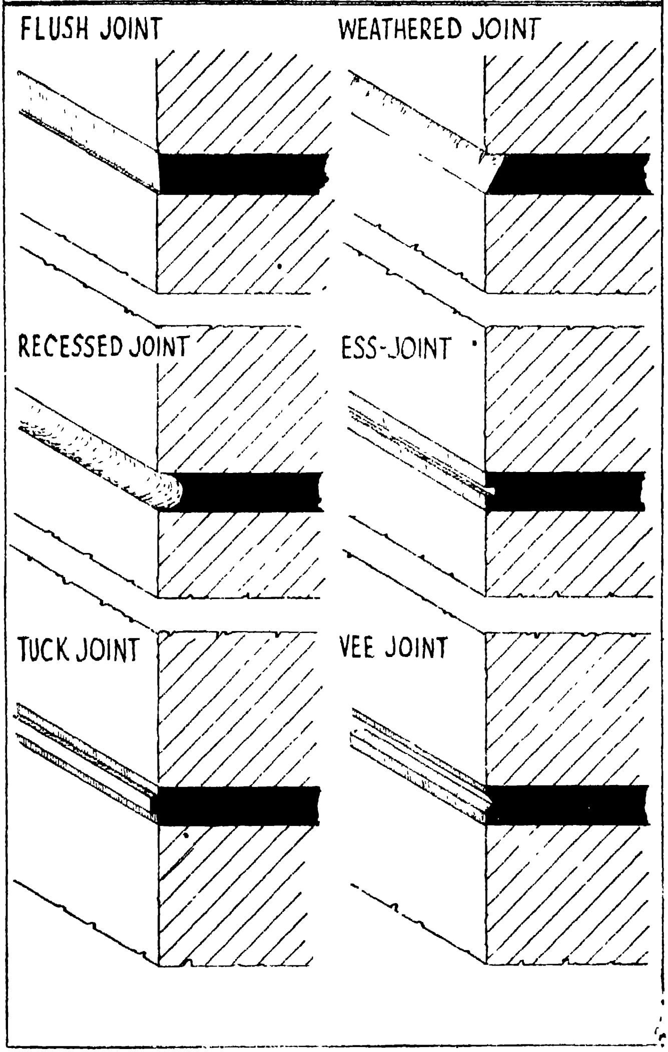
To make this joint the trowel is not held against the bottom arris of the top brick, as in weather pointing, but against the top edge of the bottom brick for the final stroke.

There are many other types of joints, some of which have been indicated (*see* Plate XXI); but if the learner is able to make the flush joint, the weather joint and the tuck joint, then he will have developed sufficient skill as will enable him to make the others.

Do not forget that, when re-pointing, the main points towards making a thorough job are : (1) Hack out the mortar joint for about ½ inch in depth ; (2) brush it well ; (3) damp it well ; (4) press the mortar well home as it is placed into a joint space.

As previously stated, all the cross-joints should be pointed first, but there are two exceptions to this rule. These are trowel-jointing and " S "-jointing. As long a continuous line as possible is first drawn by placing the long straight-edge—which should be at least 12 feet long—in the centre of the mortar joint, and the trowel or S-jointer rested upon it and passed in one movement along its entire length. If

PLATE XXI. FINISHES TO JOINTS



this is done in short lengths the joint develops a wavy appearance and is spoilt. After the completion of all the bed-joints, the cross-joints are next finished by holding the plumb-rule vertically and centrally to one cross-joint and then by stroking each joint to which the rule has been applied, with the jointer.

Keeping the Perpends

By this means the cross-joints are kept in a perpendicular line or, as it is termed, " the perpends are kept."

Good workmanship is always enhanced by the quality of its finish, and this remark is especially applicable to brickwork. Any one of the foregoing types of jointing may be used for the finishing to new brickwork as the job proceeds, as well as for re-pointing old work.

from this datum mark if the ground should be more or less level. But, if the walls are to be built upon an inclined site, then the footings and the damp-proof course will have to be stepped to coincide with the steps, or differences in level, that will have been made when excavating the ground.

Bitumen Roll D.P.C.

For all normal damp-proofing purposes the bitumen roll is the easiest and the most economical of all damp-proof materials. It consists of a thin layer of non-viscous bituminous material, about ⅜ inch thick and made with a hessian base.

In exceptionally hot weather the bitumen becomes fairly soft and can be unrolled without any serious defect occurring, but when the weather is cold care must be taken when unrolling it, or otherwise cracks will occur.

This condition is not serious, but before the material is laid into position on the wall place it in a warm room for a while and it will then become more viscous and not so brittle.

Should any cracks occur in the material, the mortar will find its way into them and prevent them from being effectively sealed up.

To strengthen or reinforce the material, a hessian base is placed in the centre of its thickness so as to form a core. In the better types of material this hessian core is sometimes substituted by a foil of copper or lead interlining which has the effect of not only reinforcing the material but of acting as an extra damp-resisting material. At the same time the bitumen tends to protect the material when in contact with the mortar in the joint.

To lay the bitumen roll, cut the string with which it is secured and, placing the roll at the end of the wall, loosen one end and place a couple of bricks upon it, then unroll it out backwards and always keep the back down until the other end of the wall is reached or the roll is completely unwound, or the wall changes direction (*see* Plate XXIII).

To make the joint between two pieces of material, allow a cover, or lap, of at least 3 inches to prevent the by-passing of the moisture. When it is necessary to change the direction of the d.p.c., the material must be cut completely and the severed portion placed on to the other, again forming a 3-inch lap and unrolling on the new wall (*see* upper sketch Plate XXIV).

Do not try to form a mitre by doubling the material as this will bring three thicknesses of material at one part, which will make an unequal bed-joint, and do not cut the mitre unless the whole of it can be covered with a patch of the same material.

When finally fixing the layer of material keep its edge about ½ inch back from the face of the wall. This will leave a clear space on the face of the bed-joint, which may afterwards be pointed with mortar. The object of this is that the mortar will prevent the exudation of the bitumen from the wall during hot weather, as blobs of this material will soon spoil the face of good brickwork.

Impervious Brick D.P.C.

An excellent, cheap and effective d.p.c. can be made by setting one or two courses of hard impervious blue or red bricks in Portland cement mortar all around the job. To make certain of its efficacy, rake out any mortar that may have fallen into the cross-joints, because the mortar may be pervious to moisture and then the damp would rise through the bed as well as the cross-joints.

Hot-laid Mastic Asphalt D.P.C.

By far the most expensive method of forming a damp-proof course is to use mastic asphalt.

Blocks of the natural rock asphalt are placed into a melting-pot and whilst being heated a certain quantity of pure bitumen is added to obtain the correct consistency and to assist in converting the material into a workable condition.

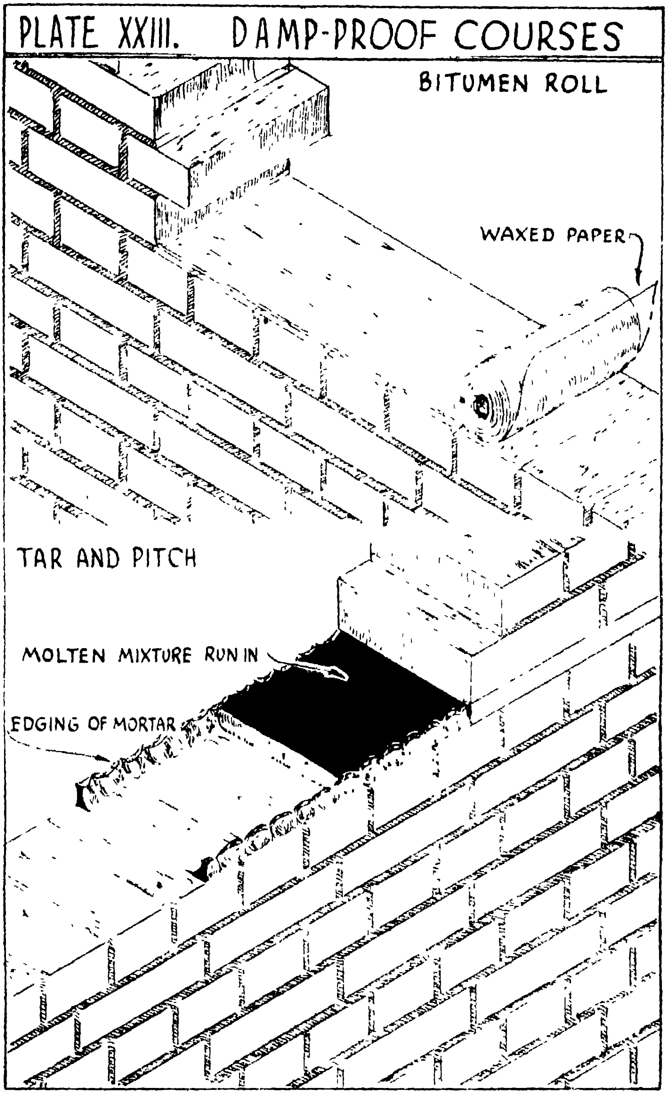


PLATE XXIII. DAMP-PROOF COURSES
BITUMEN ROLL
WAXED PAPER
TAR AND PITCH
MOLTEN MIXTURE RUN IN
EDGING OF MORTAR

The material is then taken out of the melting-pot and spread upon the wall by means of a small bull-nosed laying trowel and another with a wooden " float." It is always advisable to lay the asphalt course in two separate coats or layers so as to prevent subsequent cracking. But as this is an expert's job the matter will not be discussed any further (*see* lower sketch Plate XXII).

Tar, Pitch and Sand D.P.C.

Tar, pitch and sand form an excellent, cheap damp-proof course when melted in a boiler. The molten mixture is then placed into buckets and poured on to the wall. As this material runs very freely when hot, an edging of mortar should be spread around that portion of the wall which is to be covered (*see* Plate XXIII). The mortar should be placed on both edges of the wall to prevent it from over-running the sides. On cooling, this mixture will solidify and form a continuous and impermeable layer over all the bed surface of the walls and subsequent joints can be made quite easily.

There is, however, one fault that is likely to occur with this type of d.p.c. and it is that, in extremely cold weather, the material is apt to become brittle and to crack very easily.

Otherwise, it is a cheap damp-proof course, and under normal conditions very efficient.

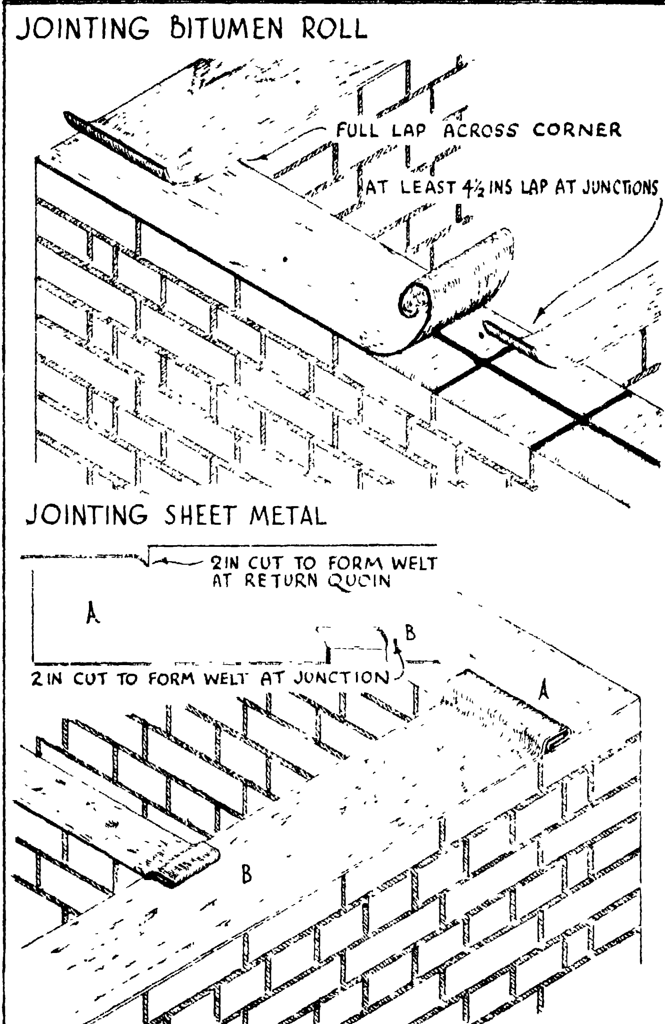
Sheet Metal D.P.C.

Sheets of lead or copper fulfil the same functions and in the same manner as bitumen rolls so far as general laying conditions are concerned, the only major difference being in the formation of the joints.

With these materials the joints should be turned over and made in the form of welted seams (*see* Plate XXIV).

One fault of non-ferrous metallic damp-proof course materials is that they are liable to decay when attacked by the salts in the damp mortar and as a result their effective thickness may become reduced.

PLATE XXIV. DAMP-PROOF COURSES



Slates and Cement D.P.C.

A very good form of d.p.c. may be constructed by laying a double course of slates in cement mortar. Ordinary good second-hand slates will do for the job. The mortar should be composed of two parts clean sand and of one part of Portland cement.

To form the course, lay the first course of slates on a good thick bed of mortar and allow the mortar to stiffen, then repeat the procedure with the second course, this time breaking the joints with those of the slates underneath (*see* upper sketch Plate XXII). On the top of this course spread some more mortar so that the bed is evened up and levelled for the commencement of the ordinary brickwork of the superstructure.

Sometimes an undue strain is placed upon the damp-proof course owing to an unequal settlement of the walls. In such cases the slates are liable to crack and give way owing to the exertion of extreme pressure on the slates. This damage is not considered to be a very serious matter and the possibility of its occurrence is very remote.

For the beginner, slate damp-proof courses are the easiest to lay, as they require very little practical skill, when bitumen rolls are not available or when there is a surplus of slates that must be used up.

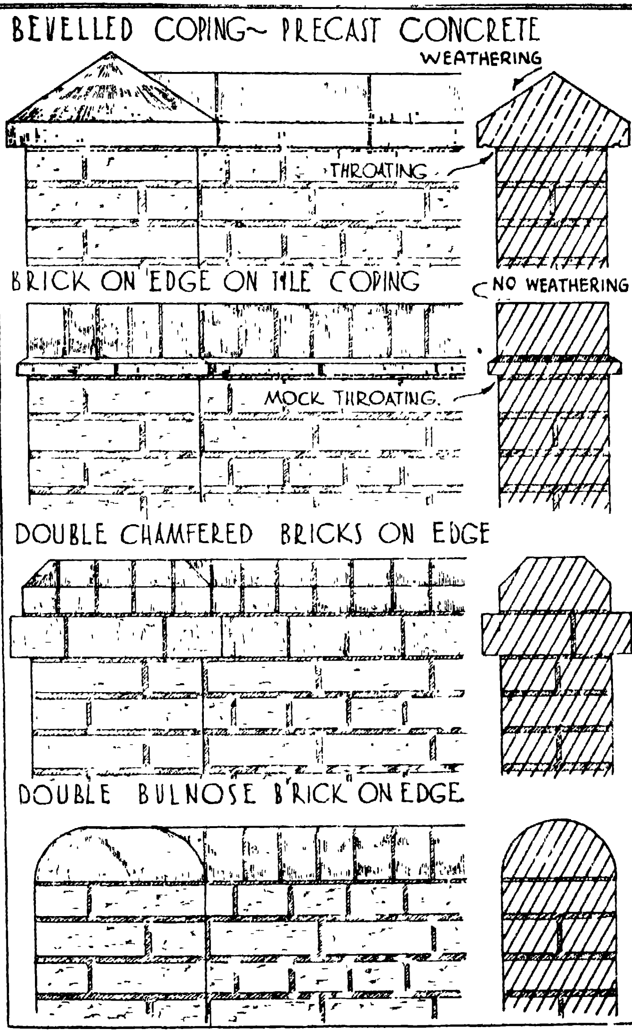
All the foregoing remarks apply to the prevention of moisture passing upwards and along a wall; they are, in most cases, also applicable to the prevention of moisture filtering down a wall.

Wall-covers or Copings

To protect a wall from becoming saturated by rain, or snow, it should be finished with a cap or a projecting course of coping.

Caps for this purpose can be made at home, in much the same manner as that described for concrete bricks; all that is needed being the requisite wood mould. Alternatively they can be purchased ready made in the form of pre-cast units. Other forms of coping are possible, weathered stone

PLATE XXV. CAPS AND COPINGS



blocks and a course of bricks laid on their edges upon a course of tiles being two types of construction in general use (*see* Plate XXV).

A rather difficult problem arises when dealing with the prevention of water passing sideways through a wall because it is not easy to find the spot where the leak occurs.

Penetration of Moisture

Sometimes the dampness in the wall is due to driving rain penetrating through some of the porous bricks, or it may be due to heaps of soil or similar material being piled against the base of the wall; or sometimes, as in the case of sub-basements, by contact with the surrounding ground.

In the first case, which is an instance of bad brickwork, and as the problem is a very difficult one to solve, no definite cure for the defect can be guaranteed.

Remedying Defective Brickwork

Probably the best way to remedy the fault is to wash the face of the wall with clean water, using a fairly stiff brush, then allow the surface to dry thoroughly, afterwards applying a coating of linseed oil, or a coating of silicate of soda (solution P84). Another method is to wash the wall with a cement grout to which is added a liberal amount of common salt. It is preferable to apply the grout in two thin coats rather than a thick one.

By rendering the wall with two coats of cement and sand mortar, or by rough-casting, or pebble dashing, it will be found that a possible cure may be effected.

With the exception of the last two processes the others may only be termed expedients and not cures. If the cause of the dampness is attributable to soil or other similar materials, then the remedy is to remove the heap of material from the wall, thus breaking contact and thereby preventing the moisture being drawn away from the ground through the material and into the wall.

A similar remedy may be applied where a basement is damp. This problem is best dealt with by digging a trench on the outside of the wall and leaving a clear space of about 1 foot 6 inches. The inside of the trench should be revetted by another wall which will not only sustain the bank, but will retain the earth which has been excavated from the trench.

There are many kinds of material suitable for making a vertical damp-proof course, but the best is mastic asphalt.

Inserting a New D.P.C. into an Existing Wall

Sometimes it is desirable to convert a reasonably good outbuilding into a habitable one. This can be achieved by inserting a new damp-proof course in the walls or by replacing the existing one which has become deteriorated by age. In such case it is advisable to use bitumen roll or slates in cement.

The first step in the process is to divide the wall into portions of about three bricks long, commencing at one corner and then working towards the middle. And starting at the middle portion, proceed towards the other corner of the wall. By working to this arrangement it is possible to prevent too large a portion of the wall remaining unsupported at any given time and to distribute the superincumbent weight evenly over the supported portions.

To cut out the patch of brickwork proceed in the same manner as described for removing decayed brickwork and chase cutting as described in Chapter IV; but in this instance proceed laterally and not vertically.

Do not make the hole more than three bricks by the thickness of the wall and never more than three courses high. Always try to arrange that the hole is covered in by a heading course, as heading bricks have a better mutual support than stretchers.

Having prepared the hole in the brickwork, place the damp-proofing material into position as quickly as possible and then make good the wall by building the brickwork

and tightly replacing the bricks by "pinning up" the last course of bricks. The empty space should be filled in as soon as possible, and do not cut out a hole and then leave it over-night to be filled in the next morning.

Do not leave brickwork suspended—that is, without a direct support—no matter how safe it may appear to be. If you must go away, the brickwork should be propped up with timber struts so as to render it safe and sound.

Before the last course is laid, see that the bricks are a tight fit when they are placed in the hole, and having done this, do not spare the mortar but line the hole with mortar and drive the brick home by placing a stout piece of wood over the brick and forcing it with a lump-hammer.

This precaution will prevent the brick from becoming fractured by the sharp blows of the hammer.

Rendering Walls

Supposing it has been decided to repair the wall by treatment with stucco or with pebble-dash, it is desirable that a new brick base be inserted on the face of the existing wall. Or failing this, a surface rendering of cement mortar—which has been specially water-proofed—placed to a height of at least 1 foot 6 inches above the ground level, will be found to be sufficient to prevent the spread of damp along and through the wall.

Leaky Roofs

Faults in roofs are sometimes caused by defects in the lead flashings and soakers, which are pieces of sheet metal, so placed as to cover the joints between the walls and the roof. A simple way of stopping such a leak is to run a triangular fillet of cement mortar down the junction of the roof surface and the wall. Alternatively a course of tiles can be inserted into the wall and allowed to project for an inch or so from the wall face so that they can shield the angle formed by the roof and wall from the driving rain and snow.

Label Courses

Arch and lintol surfaces may be protected in a similar manner by placing a protecting course of tiles or bricks immediately over the head of the arch or lintol which will shed any water that may have run down the wall-face. Such projecting courses as these are termed label courses and they are protected by a fillet of cement mortar which is placed at the meeting of the wall-face and the top of the projecting course.

Very often a covering of cement mortar is placed on the top of a wall to protect it from the downward penetration of rain, but it is an entirely unsatisfactory method as the cement is liable to crack and to peel off, thus leaving the joints further exposed.

Tops of walls should always be protected by efficient copings projecting beyond the face of the wall, thereby shedding the rain-water clear of the wall surfaces.

CHAPTER VII

DRAINS AND MANHOLES

The Drainage System

THERE is something apparently obscure about the working of a drainage system and it is to be regretted that the average man is not very familiar with the principles by which it operates. As it is based upon the simplest of scientific principles applied in a practical manner, there is nothing to be afraid of.

Whether you dislike the mention of drains or not, a considerable amount of time and money will be saved if a few of the elementary facts concerning the working of drainage systems are understood.

It is for this reason, and because it is part of a bricklayer's work, that it is introduced into this book.

When it is known that a drain is a system of pipes for the conveyance of household waste matter by means of the water-carriage method, you have learned the meaning of the word drain.

There are two types of drainage systems: one is the "dual" system into which every kind of waste water as well as solid matter is emptied, and the other is the "separate" type in which two sets of pipes are needed—one for the conveyance of storm water (which is relatively clean) and the other for the removal of foul solid matter and waste water.

Ventilation of Drains

Drains must be adequately ventilated, and to do this effectively the system must be provided with both a fresh-air inlet and a foul-air outlet. These openings are placed at the ground level or near to the manhole (or inspection chamber) and at the highest part of the buildings respectively.

The drain-pipes should be given a fall such as will cause them to be cleared out as the contents pass along them. It is just as wrong to lay the drain-pipes with too steep a "fall" as it is to lay them horizontally and without a "fall."

Drain-pipes should be made from salt-glazed stoneware —not earthenware—and provided with a spigot and socket ends. They should be perfectly circular in the barrel, straight from end to end, and be free from fire-cracks or blisters, and they should also ring like a bell when struck together.

Drainage fittings should also be made of glazed stoneware, and gullies and disconnecting fittings should be provided with proper traps. This detail is only mentioned because, although it is not possible for the bricklayer to control their manufacture at the works, he should at least know something about them.

The average good-class builders' merchant will supply any of the proper fittings, as they are now more or less standardised and provided with efficient water seals, streamlined bores, and are practically fool-proof.

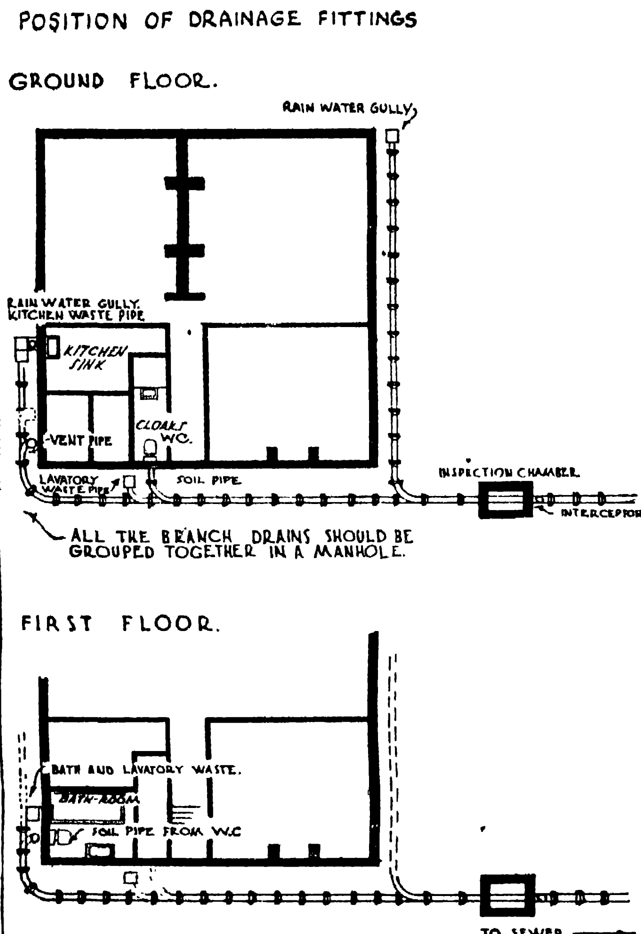
What is important is that the proper position of the fittings in the drainage system should be known as well as their separate functions.

The Gradient of the Drain

To commence the laying of a drain, it is first necessary to fix the heights of the gullies and the manholes, as well as the interceptors or disconnecting traps. By this means it will be possible to ascertain the amount of fall to give to the bottom of the trench, and this should be parallel to the gradient, for it is upon this that the concrete is laid which will in turn support the drain-pipes.

To determine the correct amount of "fall" for drain-pipes which will cause the pipes to produce such a velocity as will not allow any solids to collect in the fittings, traps and so on, a rule of thumb, or empirical, formula has been evolved which is known as Maguire's formula. This is as

PLATE XXVI. LAYING A DRAIN



THE LAY-OUT OF THIS DRAINAGE SYSTEM IS NOT INTENDED TO BE REPRESENTATIVE OF THE MODEL BY-LAWS BUT TYPICAL OF THE PREVAILING SYSTEMS.

follows : To obtain the correct amount of "fall" for a drain of diameter "d" inches, multiply "d" by 10, the fall is then 1 in 10 "d" and this can be expressed as 1 in 10 "d" inches, or 1 in 10 feet.

Therefore, for a 4-inch drain-pipe, the correct fall to which it should be laid is 1 in 40. For a 6-inch pipe the fall should be 1 in 60, and for a 3-inch pipe a fall of 1 in 30.

It would be well to note that this result represents the minimum fall and should not be reduced under any circumstances (*see* upper diagram Plate XXVII).

Foundation for a Drain

It is always recommended that a layer of concrete, about 4 inches to 5 inches thick, should be provided for the pipes to rest upon and to prevent the pipes or their joints from fracturing. This is liable to occur when the building settles, or when heavy weights are passed over the drain. The inclusion of a good thick layer of concrete is essential if this settlement is to be prevented, or where there is reason to doubt the solidity of the soil. The provision of this concrete support is expensive; but if the ground is weak, or likely to fail, the expense is well justified. It is always cheaper to form the concrete support whilst the ground is open than to have cause to re-excavate the ground in order to repair the damaged pipe.

Also, it is far more congenial to lay a new drain than to repair one that is being used.

Practical Drain-laying

Having now prepared the concrete bed for the pipes and fittings, commence by laying the first pipe at the manhole junction in the case of the branch drain, and at the interceptor in the case of the main drain. The spigot end of the pipe should be placed towards the sewer and then the socket end will be facing the fitting.

A good plan is to lay the pipe loosely on a brick on edge about 1 foot 6 inches below the socket, so that the pipe is

raised above the concrete raft or the bottom of the trench, as the case may be (*see* Plate XXVII).

By lifting the pipe in this manner it is possible to place the hand underneath the pipe when making good to the joint with the mortar, otherwise, if the pipe be not raised, it would be found to be impossible to ensure a perfect joint.

To make the joint it will be necessary to mix some mortar comprising equal parts of cement and sand; but sometimes it is advisable, and especially when the trench is in a wet condition, to use neat Portland cement. Line all around the inside of the socket with a liberal application of mortar, feathering it off at the outside, and then gently insert the spigot end of the other pipe.

Then, by applying a screwing motion, push the length of pipe until you have rammed it home; and, at the same time, don't forget to have the loose brick in the correct position to support the new length of pipe.

Next, set the pipe to its alignment by keeping the setting-out line in the centre of the pipe. The setting-out line should be stretched from end to end of the drain to give direction to the pipes, and it must not be used for giving the fall to the pipes because of the sag in the line which, unlike the bricklayer's line, cannot be eliminated.

Having laid the pipe, the next job is the process of making the joint watertight, and this is done by pressing the mortar in the space at the top of the joint and allowing it to fall to the sides and downwards to the underside of the joint. One of the reasons why it is difficult to form a good joint is because any adhesion between the materials which form the joint surfaces and the cement mortar is rendered difficult by the impermeable nature of the salt-glazing which covers the outside surface of the spigot and the inside surface of the socket. Good pipe manufacturers attempt to prevent the jointing portions of the pipe from becoming glazed by covering the respective parts with an extra band of clay during the burning of the pipes. An added key is formed by the scoring of the pipes, which is

the indenting of the pipes with a number of grooved rings which are scratched upon the pipes whilst the clay is soft.

Because of the absence of absorption by the material of which the pipes are made, it is necessary to ram the mortar in at the top of the joint and then to keep forcing it in as it slips down the side of the joint, and carefully press it fairly hard into the bottom of the joint.

Cleaning the Joint

When the joint has been firmly packed with the cement mortar, and it is in a fairly hard solid condition, a half-moon scraper should be used to clean out the joints (*see* lower sketch Plate XXVII).

Any mortar that may have been squeezed out of the joint and dropped on to the invert of the pipe whilst the new length of pipe was being pressed home, is removed by the following procedure.—

To clean out the pipe, insert the scraper into the pipe by holding the round part of the scraper against the upper surface, and when it is certain that the scraper is beyond the joint, turn the scraper towards the bottom of the joint and draw it outwards. By carrying out this process correctly, the surplus droppings will be withdrawn from the joint and brought to the open end of the pipe.

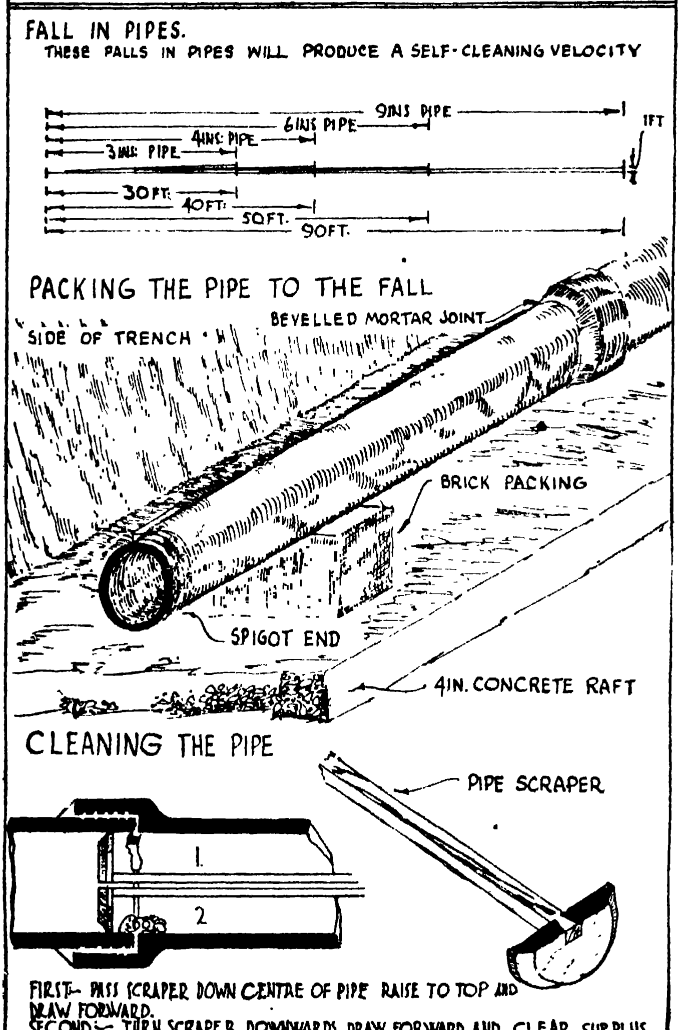
The scraping tool should be pressed against the surface of the pipe more firmly with each operation because the scraper will tend to slide over the wet mortar and consequently allow some of it to adhere to the sides of the pipe.

If left, this mortar will cause an obstruction when the drain is in use.

When it is clear that there is no more mortar remaining inside the pipe, continue laying the subsequent pipes until the fitting is reached or a complete length of drain is laid.

To make a good joint between such fittings as a gully and a bend is a rather more difficult proposition; therefore, because of this, some drain-layers prefer to start at this joint and then work towards the sewer in the opposite

PLATE XXVII. LAYING A DRAIN



manner to that already described. But I recommend the procedure already described because the pipes rest on one another and do not tend to hang or to pull apart as they would if started from the top end. The difficulty arises not in the making of the watertight joint, but in the cleaning out and the removal of the waste mortar from inside the trap.

Manholes or Inspection Chambers

If a drainage system incorporates a junction of more than two pipes, then the junction of the pipes should always be accessible for inspection, and this means that a manhole or an inspection chamber will have to be constructed.

Inspection chambers are usually built below ground level and should, whenever possible, not be more than 5 feet deep. They should always be constructed in hard bricks (not Flettons) and cement mortar.

It is a matter of importance that the water inside a manhole should not be allowed to percolate through the walls of the chamber and foul the surrounding ground. Conversely, the outside water contained in the subsoil should be prevented from passing into the manhole. Obviously then, the walls of manholes should be built in such a manner that watertightness is ensured.

Water Bond

A common practice is to employ a rather unusual type of bonding, when building the walls of the manhole, that will not allow a direct passage of water from one side of the wall to the other by means of the through cross-joints or transverse sectional bond. This bond is called water bond and is formed by staggering the cross-joint in each course, so that the face stretchers are $4\frac{1}{2}$ inches past the back stretcher. This arrangement of the bricks secures the maximum amount of stagger and is the one usually adopted in practice.

Obviously, headers cannot be used in these walls unless the walls are 14 inches thick, and then an adaptation of

non-sectional English bond should be used. This method of bonding will produce a better wall than a 9-inch wall built in water bond.

Manholes should always be built so that they are economical in size and shape, but large enough to allow a man to work inside the chamber to clear a length of drain by using cleaning rods. A plan area of 1 foot 6 inches by 2 feet 3 inches is about the minimum size for a three-way junction manhole, but this size should be increased in proportion as the number of branches is increased.

Covering the Manhole

It is usual to cover the top of the manhole with a properly fitted cast-iron inspection chamber frame and cover, which should be kept as small as possible -preferably 1 foot 6 inches square. This means that the opening will have to be reduced from 2 feet 3 inches to 1 foot 6 inches to support the framework of the lid.

The reduction may be accomplished in two ways: (1) by corbelling over each course of brick 2¼ inches at a time (this will mean two courses projected from each side, making a total overhang of 9 inches); or (2) a piece of paving slab about 2½ inches in thickness and 2 feet 3 inches by 1 foot 6 inches in area. To cover over the manhole bed the slab on to one of the narrow (1 foot 6-inch) ends, allowing it to rest 9 inches on each of the long sides. If the slab is bedded in this manner it will have a seating or wall-hold of 4½ inches.

This latter method is cheaper, better and quicker than the former method of brick corbelling.

An inspection chamber should be all that its name implies—that is, a means of access for the inspection of drains.

To assist in carrying out this inspection of the drains, the manholes should always permit of a clear view of the invert or bottom of the drains. The person carrying out this examination is thus able to see at a glance which branch is choked.

There are two kinds of open pipes employed in man-

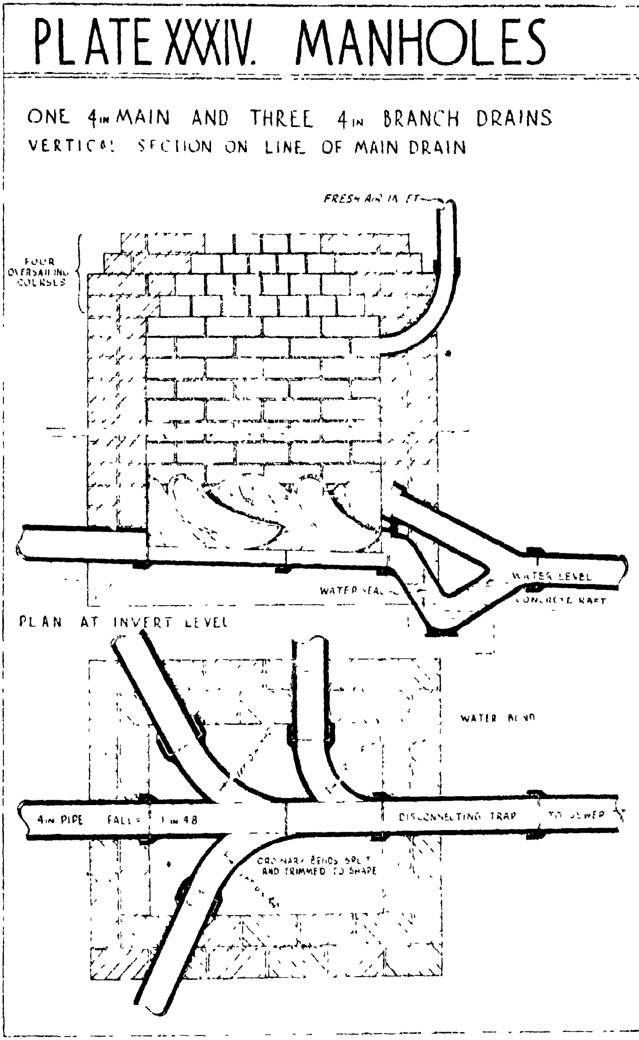


PLATE XXXIV. MANHOLES
ONE 4IN MAIN AND THREE 4IN BRANCH DRAINS
VERTICAL SECTION ON LINE OF MAIN DRAIN
FRESH AIR INLET
FOUR OVERSAILING COURSES
WATER SEAL
WATER LEVEL
CONCRETE RAFT
PLAN AT INVERT LEVEL
WATER BEND
4IN PIPE FALL = 1 IN 48
DISCONNECTING TRAP
TO SEWER
ORDINARY BENDS SPLIT AND TRIMMED TO SHAPE

holes. These are known as half-round and three-quarter-round. The former may be cut from a whole pipe with a bricklayer's scutch, but the latter must be bought ready made.

A skilled craftsman can cut two split pipes from one whole pipe, but it is almost impossible for the novice to accomplish the feat.

Split pipes are known as invert pipes because they form the bed of the drain, which is the invert.

Sewage will overflow from the open pipes and " back up " into the manhole when all the branch pipes are running full-bore, as well as the main outlet. When the flow slackens, the pressure will be relieved and the sewage should then subside into the normal channels.

Benching to Inverts

To assist in guiding back the sewage into the proper channel, the sides of the invert channel pipes are built up with concrete to form steep slopes, and this is called benching.

A disconnecting trap should be placed on the sewer side of the inspection chamber and embedded in concrete. Its function is to disconnect the sewer from the house drains and to intercept any foul sewer gases and prevent them from entering the house drains (*see* Plate XXVI). This disconnection is made by the provision of a water seal or dip which is formed in the base of the fitting.

In country districts, where sewers do not exist, a very important part of the drainage system is the provision of cesspools or septic tanks. In the former case the sewage is stored in the chamber until it is pumped out and taken away to be spread on to the land, whereas, in the latter, the sewage is left in the tank and allowed to decompose by liquefaction and then run off into filter beds for further purification.

Cesspools are built in much the same manner as inspection chambers, except that as the water must remain stagnant for a considerable length of time, every precaution

must be taken to ensure that no foul matter is allowed to percolate through the wall and thereby pollute the surrounding ground.

The best form of plan for a cesspool is a circle, and as the learner has not yet been instructed in the art of building circular brickwork, he will, of necessity, have to confine his efforts to chambers which are rectangular in plan. Also, he will have to apply his skill and knowledge in the use of the water bond as previously described.

A further safety precaution may be formed by leaving a 12-inch space between the wall-face and the existing subsoil and then to pack this space with 12 inches of solid clay which has been previously moistened or puddled.

So far as filter-beds are concerned, these are necessarily difficult to construct; therefore, the novice should not attempt to build them except under the tuition of a competent bricklayer.

Clearing Drains

The diagrams, Plate XXXIV, illustrate the construction of an inspection chamber fitted with an intercepting trap, and more familiarly called a *manhole*, and interposed between the branch drains and the sewer. This part of the drain is known as the main drain. As its name implies an inspection chamber provides a means of access to the drains which are situated below ground level and in such positions as would otherwise render them inaccessible.

When drain-pipes are blocked up it is necessary to remove the stoppage as quickly as possible by a process of rodding, plunging or flushing. Most of the drainage fittings are combined with a self-contained trap around or through which it is not practicable to push a cane or rod. Therefore it is not possible to clear the stoppage from the fitting and access must be provided for a straight length of rodding clear of all traps.

There are two ways of doing this: one is by the provision of rodding eyes, and the other by building a manhole or inspection chamber at each end of a straight drain.

Rodding Eyes

Rodding eyes should be placed where bends occur and either in front of or behind the disconnecting trap or interceptor. In effect, a rodding eye is formed in an opening, on the top of a drain-pipe provided with a socket which is the base connecting a vertical shaft of drain-pipes to the drains. The pipes are carried up to ground level and sealed at the top to prevent the escape of foul smells, and it is through this shaft that the drain rods are passed when it is required to remove obstructions from the drain.

Rodding eyes are cheaper to construct than manholes, but they are not so effective.

Inspection Chambers

At the point where a drain changes direction and close to the disconnecting trap there should always be a means of access to the drain, and the best means of access is provided by an inspection chamber.

There are many ideas concerning the plan of manholes, but probably the best arrangement is one where the longest side of the chamber is parallel to the main drain. This is not always possible, however, as sometimes the drain is on the sweep, or curved. A cheap form of construction for a manhole is one in which the walls are built of pre-cast concrete section and circular in plan.

Whatever the shape of the plan, a manhole is useless if it is not large enough for a man to be able to manipulate a 2-foot rod at the bottom. A manhole should be 2 feet 7½ inches to 3 feet in length, as the rods must be placed parallel with the invert of the drain to be effective.

To avoid pushing the rods through the trap of the interceptor a special arm or pipe is incorporated on to the fitting, as shown on Plate XXXIV. Usually this arm is slightly less in diameter than the drain; so do not attempt to ram a 4-inch disc plunger down a 3-inch rodding arm. The ordinary double screw and wheel may be inserted without causing any serious ill-effects.

Building the Chamber

The first process is to lay the drain, including the disconnecting trap, upon the concrete benching, then set out the base of the chamber and place the concrete for the foundation, keeping the top surface of the concrete the same level as the pipe raft. The brickwork for the chamber walls can now be commenced. Carefully cut the bricks to fit around the drain-pipes and the interceptor and rodding arm.

The brickwork should be built with stretchers and these should not be laid with their ends in line to form through joints as in sectional bond. The bricks should be laid so that the end of the outside brick coincides with the centre of the stretching face of the inside brick, thus ensuring that the joint becomes staggered or non-sectional. This bond is known as "water bond."

The theory behind this *staggering* arrangement is that moisture is prevented from passing through the wall. Good cement mortar of equal parts of Portland cement and clean sharp sand should be used throughout in conjunction with good hard sound bricks. Salt-glazed bricks have been used very considerably for the purpose but unfortunately, price precludes the use of such bricks. Whatever materials are used and method of construction adopted, the most important consideration is that the walls and floor must be rendered impervious to moisture.

Ventilation

For many years the ventilation of drains has been a subject of much controversy. It may be safely assumed that it is beneficial to have a supply of fresh air admitted to the manhole at a point as low as possible, but not too low, otherwise it may be affected by the flooding of the chamber when a stoppage in the drainage system occurs. So long as the fresh-air inlet continues to act as an inlet all is well, but sometimes the currents are reversed and objectionable smells are likely to be emitted from the manhole.

Several measures have been adopted to ensure that the duct fulfils its proper purpose as a fresh-air inlet, the most common of these being the provision of a mica-flap valve inlet. This device may not be 100 per cent. effective, but it is the most successful to date.

Reducing the Area

As previously stated, it is desirable to ensure that the base area is large enough to enable a man to stand and work the rods, which are at least 2 feet long. A suggested reasonable minimum area is 2 feet 7½ inches × 1 foot 6 inches.

The example illustrated on Plate XXXIV measures 3 feet × 2 feet 3 inches, and this is a workable size for a manhole at the junction of a main and three branch drains.

The internal base area is too wide to be covered by an ordinary cast-iron manhole cover. Although manhole covers may be bought in many sizes, the most popular covers are those ranging from 2 feet 6 inches square to 1 foot 6 inches square.

Frames and covers are best when made to the smaller sizes, and in the illustration the area has been reduced to suit a cover 1 foot 6 inches × 1 foot 6 inches. This opening may appear to be rather restricted in size, but it is ample considering that any normal man may pass through an aperture 14 inches square.

To enclose the hole, four courses of oversailing bricks are laid at each end and two courses at each side. Thus the four courses which project at regular intervals of 2¼ inches from each end total 18 inches, and the two regular projections from each side total 9 inches, and as 18 inches from 3 feet equals 18 inches, and 9 inches from 2 feet 3 inches equals 18 inches, the reduction is complete.

A cheap and very effective way is to cover over the manhole with a concrete slab, thus allowing the 18-inch hole to be placed in any position, but when the aperture

is formed with oversailing brickwork it is best placed centrally.

Disconnecting Trap

This is a very important fitting and should be connected to the drain within the curtilage at a point nearest to the sewer. In effect it is a rather weak type of syphon consisting of a cascade inlet and a weir outflow with a "dip" or water seal.

As the water and solids tumble down the cascade they are supposed to develop sufficient velocity to enable them to rise up and flow over the weir and then to continue their journey without further interruption towards the sewer.

The dip, or seal, should project for at least 1½ inches, preferably 2 inches, below the level of the weir, which in turn is the level of the water in the trap.

Bends, Junctions, Etc.

Under normal circumstances it is usual to employ junctions which are cast in one solid piece and formed so that the invert of the main drain is at the same level as the branch drain. This is a very desirable condition and should be attained if at all possible.

In consideration of cheapness and expediency, junctions are sometimes formed by placing the inlets of the various branch drains into odd-sized bends which are laid on the main drain and trimmed by the bricklayer. It will be seen that this is really a rough and ready method, and because of its cheapness it often outweighs the advantage of maintaining a smooth streamlined junction.

Benching

Between the branches, drains and the walls of the manhole, concrete is heaped up so as to form a bank. This concrete is smoothed off and surfaced to serve as a baffle and thus return to the drain any sewage that may overflow. This banking up is known as benching.

Patent Joints

From time to time various joints for drain-pipes have been placed on the market. They consist principally of a bitumastic band which is supposed to be self-sealing under almost any condition. But preference should always be given to the well-proved cement joint.

CHAPTER IX

FIREPLACES, FLUES AND CHIMNEYS

Principles of Combustion

BEFORE considering the problem of the actual building of fireplaces, it is as well to be conversant with common principles upon which the fire in the fireplace is induced to burn, and smoke to rise in the chimney flue.

Broadly, air movement is due to the difference in weight of two similar-sized columns of air—one in the flue and one outside.

The warm air inside the flue expands and is therefore—bulk for bulk—comparatively lighter in weight than the cooler air outside; consequently, the warm air rises and the cooler air takes its place. This process, along with other secondary influences, causes the fire to draw or burn properly.

When building a fireplace and a chimney breast, the following principles of construction should be borne in mind:

(*a*) The area of the fireplace opening should be restricted to the barest minimum allowed.

(*b*) The sectional area of the flue should be kept continuously regular in shape and size.

(*c*) The gatherings and mid-feathers should be effectively bonded into the surrounding and supporting brickwork.

(*d*) The flue should not be inclined at an angle of less than 30 degrees to the horizontal.

(*e*) The height of the chimney stack above the roof should be as much as possible and not less than 3 feet above the adjacent ridge of the building.

(*f*) All chimneys should be provided with a chimney cap or pot that will baffle the wind and lend stability to the structure.

Fireplaces and Firegrates

A fireplace opening should be built with just sufficient room for fixing the firegrate. Too large an opening means a lot of making up when fixing the grate; and on the other hand, too small an opening will mean a great deal of cutting away when fixing the firegrate. Therefore, it is imperative that the size and kind of grate intended for use should be borne in mind.

A grate similar in pattern to the " Triplex " needs jambs which project for at least 14 inches into the room; in fact, some patterns of grates require a depth of 18 inches. Most of the ordinary types of register grates will require as little as 9-inch jambs.

The pattern and style of the grate will also influence the area of the opening.

If the grate is to be fitted with a back boiler, then enough room must be allowed for the plumber to fix the circulation pipes and to protect them from intense direct heat.

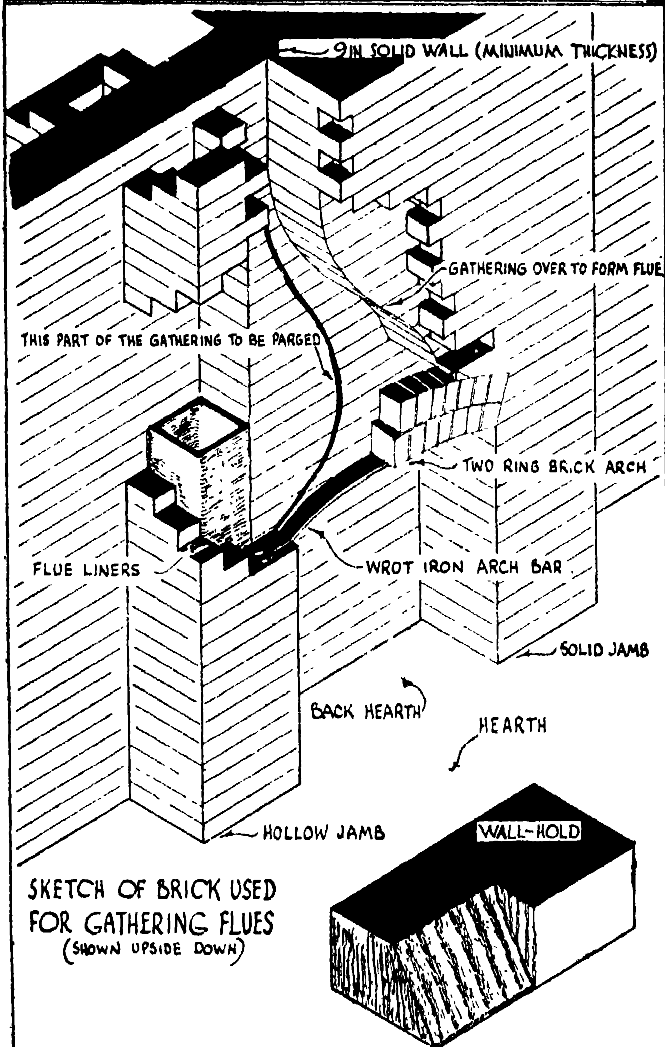
Fireplace openings are very large spaces and they should be enclosed as soon as possible by gathering over the brick-work from both sides, so that the flues may be set out to their proper formation.

In most cases the size of a flue for a coal-fired grate is 9 inches by 9 inches irrespective of whether it is for an oven-fitted grate or for the more simple type of register grate; although, in the case of a kitchen range, a flue of 14 inches by 9 inches is needed. Greatest care should be taken when building flues to ensure that they are kept to their regulation size, notwithstanding their inclination or direction. A convenient method by which the sectional area of the flue may be checked is to hold a brick square on to the side of the flue and note if it just clears the opposite side.

Covering Over the Fireplace Opening

As soon as the fireplace has been set out and the jambs built to the correct height, the opening or space between them should be covered over. This may be accomplished by means of an arch, which may be supported by a wrought-

PLATE XXVIII. FIREPLACES AND FLUES



iron bar; or, if a relatively narrow opening, by means of "welshing over." Sometimes concrete lintels are employed in this connexion, but as the heat is liable to cause them to crack and crumble, they are not recommended (*see* Plate XXVIII).

At the level of the arching over of the fireplace, the formation of the flue should commence. This is done by projecting corbelled bricks which have had their undersides cut away so as to help make a smooth face. The projecting portion formed with the cut bricks is called "gathering over" to form the flue.

The difficult task of cutting these specially shaped bricks can be dispensed with by buying special "purpose made" bricks which are known in the trade as "plinth stretchers" and at the junction with the vertical face "plinth internal stop." These special bricks are not used in their normal position but are set upside down, or in reverse position. Should it be desired to change the bond, then a plinth header will be used instead of the plinth stretcher provided the bed is changed.

The reason for mentioning specially-made bricks in this connexion is that to cut bricks for gathering over, a great amount of skill is necessary and the learner is bound to waste or spoil at least four bricks in the process of cutting one good one.

Do not forget the importance of closing over the fireplace as soon as possible and do not allow the flue to become enlarged or reduced, but keep it to its proper size—say, 9 inches by 9 inches for all ordinary fireplaces such as kitchen (oven and grate), bedroom and sitting-room (register grate), and for the larger type of fireplace such as double oven and grate range, 14 inches by 9 inches.

Gas-fire Flues

It is always necessary for hygienic reasons to provide gas-fires with a small flue, usually about 6 inches by 3 inches in sectional area. This type of flue does not require the formation of any special jambs or chimney-breast as

the flue is formed in the thickness of the wall by placing a brick-on-edge on both faces, leaving a 3-inch space in the middle.

When building a gas-flue it is essential that all surplus mortar should be kept out of the flue. This is not as easy as it sounds. Such a small cavity will not allow of the insertion of the trowel into the flue to clear away the waste mortar as it is squeezed out of the joints.

A good method of ensuring that the flue will not become blocked with mortar droppings is to place a board within the flue, but slightly smaller than it, and to the centre of which a cord has been attached. This board may be raised by means of the cord as the work proceeds.

When three courses of brickwork have been built, take hold of the cord and lift the board. The surplus mortar will thus be brought to the top surface of the wall and at the same time a little of the mortar will be smoothed into the corners of the flue.

This process will prevent any mortar adhering to the inside face of the flue, or allow it to drop into the gatherings and so choke the flue.

There are some specialist firms that make pre-cast concrete gas-flue blocks.

When properly used, they will be found more economical in labour and material than brick flues.

Regulation Sizes of Brickwork

Almost all grates are enclosed on all but one side, and the local building regulations stipulate that the minimum thickness of such enclosing brickwork must be 9 inches. This minimum thickness is a very important factor when considering the size of the chimney breast, which includes an opening, two jambs and—except in the case of dual-purpose grates—a back or a party wall.

For example, if the oven and grate have an overall width measurement of 4 feet and a height of 3 feet 6 inches with an oven which has a depth of 12 inches, then the width of the breast will need to be 4 feet plus two 9-inch jambs,

making 5 feet 6 inches. The 9-inch jambs must project at least 14 inches into the room. But a projection of 18 inches would be better and more convenient when fixing the grate. This brickwork, which measures 5 feet 6 inches wide by 14 inches deep, must be carried up to the first ceiling—unless the breast is reduced on the top of the fireplace, which is an exceptionally rare occurrence.

This may appear to be a waste of good material and labour. Therefore, for reasons of economy, a pocket may be formed between the outside of the breast and the surrounding brickwork of the flue.

No point is gained by filling up the space with solid brickwork, except possibly to strengthen the gatherings.

Lining the Flue

Ordinary coal-fires create a good deal of smoke and soot which pass along the flue in the breast as well as in the stack. This soot tends to cling to the brickwork and the smoke is liable to percolate through the faulty joints of the brickwork; therefore, special precautions must be taken to reduce these defects to a minimum.

This you can do by:—

(*a*) Pargetting the flues with mortar.

(*b*) Enclosing the flues with special liners.

(*c*) Flush jointing the brickwork on the inside of the flue.

Pargetting the flues means to render the inside surfaces of the flues with a ½-inch coat of ordinary building mortar, or mortar to which a mixture of cow-dung has been added, or plasterer's hair-mortar.

Ordinary building mortar has already been described. Pargetting with a mixture of mortar and cow-dung may seem to be an offensive and malodorous operation, but it is not as bad as it appears as there is no objectionable smell when the ingredients are properly mixed.

However, it is to be strongly recommended as an absolutely efficacious method of lining flues. Ordinary mortar is liable to lose its nature when subjected to heat and then

crack and flake away. Cow-dung mortar has the power of resisting the heat of an ordinary coal-fire and should be used whenever possible. Much the same as cow-dung can be said with regard to hair-mortar.

The two principal types of flue-liners are made from salt-glazed stoneware (the same material as is used for drain-pipes) and a composition of asbestos and Portland cement.

Stoneware linings are either made in one complete piece or in separate sections for each side. Those that are made in one piece are either circular or rectangular in section; they are usually 2 feet in length and are made without a socketed joint.

For larger flues—that is, for flues of 14 inches by 9 inches—the square liners are made in four pieces, or sections, and mitred angles. Butt-jointed angles, although made and used, are not to be recommended as their sides may topple over and so close the flue, whereas, with mitred joints the slabs become interlocked and cannot be disturbed. Stoneware liners present a reasonably large unbroken surface to the passage of the smoke and thus prevent it passing through any weak brickwork joints. Also, the smooth salt-glazed surface prevents the adhesion and collection of particles of soot in the flue.

The type of flue-liner much favoured on the Continent is the one moulded from cement and asbestos, which is quite cheap in cost and very efficient in working. Note well, however, that the material used is very thin and that it should never be used by itself but always encased in at least 4½ inches of brickwork.

A good and cheap method of sealing the surfaces of a flue is to point the joints of the brickwork in the form of a flush joint, thereby compressing the mortar in the joints and at the same time smoothing the surface of the flue. It is the texture of the bricks employed that will determine, very largely, the extent to which the soot will adhere to the sides of the flue.

For instance, if common wire-cuts are used their rough surfaces will provide a grip for the soot; but if, on the other

hand, red pressed bricks are used, a smooth surface is presented to the soot which allows it to pass uninterruptedly upwards and out at the top of the chimney.

Coring a Flue

A further method of forming the flue—although it may seem rough and ready—is to core it around a drum. To do this, procure an ordinary sheet steel oil drum, about 10 inches or 12 inches in diameter, and place it into the position to be occupied by the flue. Then get a half-brick and put some mortar very thickly upon one end. Now force this bat tightly against the drum and the mortar which was on its end will be pressed so as to conform to the circular shape of the drum.

More half-bricks are laid around the drum to complete the circle in one course.

Continue this process for three or four courses, then withdraw the drum about 6 inches by twisting it upwards to prevent it being gripped by the setting mortar.

Not only can the vertical portions of the flue be built in this manner, but also the oblique parts which are always difficult to build even by ordinary methods.

After the flue has been set out—which, of course, must be above the fireplace opening—the brickwork enclosing the flue may be reduced to 4½ inches thick.

This means that the flue can now rest upon the outside or the party wall for 4½ inches, thus effecting a considerable economy in space.

For all smoke flues a minimum surrounding thickness of 4½ inches is demanded by local building bye-laws.

In the building of groups of flues or chimney-stacks, this minimum must be maintained between flue and flue, as well as between flue and outside wall.

Of course, a 9-inch outside wall is better than a 4½-inch wall, especially when the mortar is friable and the weather is liable to open the joints, thus allowing the cold air to pass inwards or the smoke to pass outwards.

The piece of wall between the two flues is called a

" withe " or " " midfeather " and this must be, as previously stated, at least 4½ inches.

This rule applies to every case, even when the special flue liners are used.

Do not try to eliminate the midfeather by placing two flue-liners back to back, as they will crack and break unless they have a solid brick backing. Also, the building bye-laws will be contravened.

Finally, we come to the chimney-stack proper. The term stack applies to that portion of the brickwork which contains the flues and rises above the surface of the roof of the building, and is, therefore, fully exposed to the weather.

Stability of a Chimney

The first thing to consider when designing a chimney is its stability, and for this purpose no account must be taken of any possible values of frictional resistance when dealing with this problem.

The two chief things to consider are : (1) the weight of the mass of brickwork and (2) the area of the surface exposed to the wind.

Because the stack is hollow, and therefore not as heavy as a solid mass of brickwork, the authorities will not allow you to build it higher than four times its greatest width at its base when built in lime mortar, and six times its greatest width if it is built in Portland cement mortar.

It is in instances of this practical nature that the recognised advantage of cement mortar over lime mortar is appreciated.

Outlets to flues must always remain open to the air.

Chimney Caps

Several devices have been suggested and experimented with by means of which the hot air and smoke can pass into the open air freely and not be prevented from so doing by opposing winds.

It is against all the canons of good brickwork designing

to use chimney-pots or any other artificial aids to increase the draught of a chimney.

As it is considered undesirable to use chimney-pots on a chimney-stack, and yet have some guarantee that the chimney flue will not be a smoky one, an excellent finish may be found by placing half-bricks two courses high on each corner of the chimney-stack or flue, and then cover over the flue with a "York" flag or a concrete slab.

This arrangement will produce an excellent—although somewhat plain—form of cap.

To assist in baffling the wind, so that it does not blow sharply across the top of the chimney-pot, several types of louvres have been devised and which are more or less successful.

It is common practice nowadays to give the chimney-stacks an attenuated effect by denuding them of all embellishments; however, there still remains a lot to be said for giving a chimney-stack a good base and a fairly heavy cap, if only as a means to increase its stability by the addition of the extra weight.

Heavy and projecting caps are liable to baffle the wind and thereby to prevent the rising smoke to escape and consequently retaining it within the flue. This retention of the smoke will result in the newly formed smoke being unable to ascend and consequently it billows out into the room.

To set a chimney-pot is not an easy task. The beginner would be well advised to confine his attempts to pots less than 2 feet in height.

Commence to set the pot, after having levelled the brickwork, by placing a small piece of slate, roughly 6 inches square, diagonally upon each corner of the flue.

If this is not done the pot will rest upon each side of the flue and the corners will remain open. But, if after having laid the pieces of slate and thereby sealed the corners, a half-brick is bedded over them and the mortar pressed tightly up against the pots a secure fastening is ensured (*see* Plate XXIX).

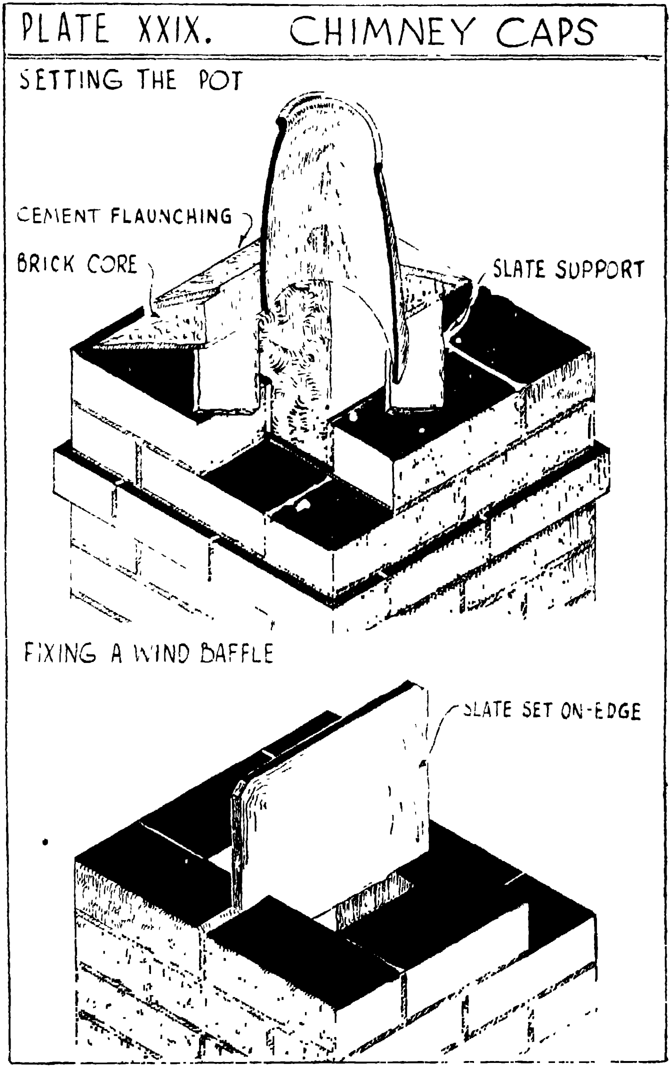


PLATE XXIX. CHIMNEY CAPS
SETTING THE POT
CEMENT FLAUNCHING
BRICK CORE
SLATE SUPPORT
FIXING A WIND BAFFLE
SLATE SET ON-EDGE

If this is not done the pots will blow off, especially if they are situated in an exposed position and not weighted at the base.

A cheap and effective wind baffle may be formed by bedding a slate so that at least 6 inches of it projects above the top of the stack. The slate should be placed so that it is at right angles to the prevailing wind (*see* Plate XXIX). As this wind strikes the baffle it is deflected, the smoke behind the slate rises up the other half of the flue behind the slate and thus escapes into the open air.

To protect the chimney caps from the effects of the weather, all chimney-pots should be flaunched and the top surface of the stack covered with cement mortar.

One of the most difficult parts of the operation of setting a chimney-pot is that of fixing it truly vertical. So, to plumb a chimney-pot it is necessary to have someone to stand upon the ground to sight it for you, as it is impossible to plumb the pot whilst standing on the scaffold because of its peculiar battering shape; and circular pots are more difficult to plumb than square ones.

CHAPTER X

SPECIAL FEATURES OF BRICKWORK

Setting a Washing Copper

IN the main the foregoing chapter dealt with the construction of flues and fireplaces and chimney-stacks in general, and in the main the remarks may be applied to chimneys other than house chimneys, fireplaces, etc.

A more difficult proposition is the setting of an ordinary copper (or boiler), and it requires a fair amount of knowledge and experience in order to be able to complete the job satisfactorily.

It is important to remember, when tackling this job, that the shell of brickwork which so effectively shields a copper is only 4½ inches thick. There must be sufficient space between the copper and the flue, which is next to and against the thin iron-work. Also, the outside brick sizes on plan must be kept down to the minimum. If this latter is not done the casing of the copper will become inconveniently large.

Types of Draughts

As the style of the setting has an important bearing on the working of the boiler, three different methods of forming the flues will now be described. They are :

(*a*) The open draught.
(*b*) The split draught.
(*c*) The wheel draught.

All coppers must have a cast-iron firebox which usually —though not always—includes the bottom fire-bars and an ash-hole for clearing the spent coals.

To arrive at the correct size for plan, at least 4½ inches must be allowed beyond the top flange of the pan and the square of the plan will be set out as follows : Diameter of pan 24 inches, flange 1 inch, brickwork 4½ inches, equals 24 inches plus 2 inches plus 9 inches equals 2 feet 11 inches square.

More often than not the copper is placed into an internal angle, and when placed in such a position quite a large amount of brickwork can be saved.

Having decided upon the shape and size of the brickwork, leave a space for the ash-hole and build up the brickwork to a height of two courses. Upon this brickwork rest the firebars and firebox frame.

The Open-Draught Method

Suppose the open-draught method is discussed first, as it is the easiest to construct.

Continue with the next course of bricks by lining the space around the fire-bars with fire-bricks. Then level the course right through and carry on with the outside 4½-inch shell until the required height is reached, which will be 3 inches below the finished level of the top of the copper.

Fill out all the corners so that they roughly conform to the shape of the copper, and then finish off the corners by smoothing them with mortar.

It will be seen that no part of the copper is in direct contact with the brickwork, and the operation is completed by placing the copper into its final position by allowing it to rest upon three or four bricks which are used as temporary packings.

Completely enclose the space between the boiler and the brickwork by setting heading bricks, the tails of which have been specially cut to fit closely to the shape of the boiler.

These headers should fit securely underneath the rim or flange of the cast-iron boiler and thereby hold it in a suspended position.

Finally, remove the packing as the sealing-off proceeds and then flaunch the top surface of the brickwork with a gauging of mortar composed of two parts of finely crushed granite with dust, and one part of Portland cement. An excellent boiler cover may be provided by a 2½-inch "York" flag having a hole cut in it to receive the flange of boiler. However, to ensure success, the flag must be firmly bedded upon a sealing course of brickwork, as previously described.

The Split-draught Method

The split-draught method is somewhat similar for the first two courses as for the open-draught method. Next, the end of the firebox is built up on the top of the fire-bars, leaving the sides of the firebox completely open.

The boiler is now rested upon the brickwork at the end of the firebox and the brickwork raised around the seating. After this the pan is removed and the brickwork shell is completed by building the outside 4½ inches of brickwork and casing the corners which are built slightly stronger than the walls.

It is because the brickwork at the back of the boiler is built solid that the hot gases are diverted or split—hence the name of the method "split draught." The boiler may be covered in by either of the methods previously described.

The Wheel-draught Method

Last and best is the wheel-draught method, because the maximum calorific value is obtained from the fuel used by the means of a helical flue. This winding flue is built around the boiler. One side and the end of the firebox are enclosed with fire-bricks, the open side being left to form the flue which is gradually reduced in size so that it is about 4 inches wide by 3 inches deep for the greater part of its length.

It is the brickwork, which must be properly cut and set, which makes three sides of the flue as the last remaining side is formed by the ironwork of the pan itself, and to which the bricks are made to fit very snugly.

One complete circuit of the boiler is made by the flue so that, when it reaches to within 3 inches of the top of the boiler, it is situated at the back of the copper and in a position to join with or enter the main flue.

Building a Greenhouse Boiler

Building a greenhouse boiler is somewhat of a rather different proposition. So far as the boiler itself is concerned, there is little or no brickwork to contend with as, apart from the front and the end, all the sections are similar.

There is no need to gather the flue as it is brought together to fit a cast-iron pipe which is usually situated at the top of the boiler and should always be above ground level.

Therefore, it is necessary to set out the base of the stack large enough to take the flue with its protecting brickwork —but not to include the boiler.

Building a Large Chimney-stack

Usually, a 14-inch square flue is ample for most boilers, which means that the base will be 2 feet 7½ inches square when measured on the outside. Until a height equal to one-third the total height of the stack is reached, the work should be kept plumb. At this level the brickwork may be reduced by two courses of plinth bricks to a thickness of 4½ inches for the remaining two-thirds of its height, which should never exceed six times the length of its base.

An effective top to a chimney-stack may be made by oversailing the cap until the brickwork becomes restored to its original thickness of 9 inches for a height of about four courses.

A further addition of a 12-inch glazed stoneware drain-pipe placed so that its socket is secured by two courses of brickwork which have been set in cement mortar, the remaining 1 foot 6 inches of the drain-pipe being allowed to project above the cap of the chimney, will increase the draught.

A firm base is required for such a heavy pipe, otherwise it will overbalance and pull a part of the chimney-stack down with it.

By increasing the thickness of the brickwork at the cap of a chimney the wind is deflected sideways and upwards so that its striking force is considerably reduced.

Waterproof Basement Walls

As greenhouse boilers are generally built in a pit below ground level, the following outline is given to explain the best way to prepare the chamber.

Excavate sufficient ground to receive the boiler, the base

of the chimney-stack, fuel bunker and ash chamber, taking care not to make the mistake of setting the job out so small as to hold only the boiler.

Having excavated the ground for about 2 feet more than the nett area, cover the site with concrete to which a water-proofing compound has been added. Whilst the concrete is still green, place two 3-inch thick planks upon it, and place them 3 inches apart, which space is then filled in with concrete. This will make an upstand of 3 inches by 3 inches all around the boiler-house, and will be the base of the core of a 12-inch retaining wall. Build the outside shell of 4½-inch brickwork for about four or five courses and then raise the inside brickwork by the same amount.

When these two 4½-inch walls are levelled, fill in the cavity with concrete of the same mixture as was used for the floor. After the concrete is levelled the process must be repeated, but not so as to raise the wall for more than five courses at a time.

Failure to regard this rule will mean that the brickwork will tend to bulge and swell. Further strengthening may be obtained by placing special iron ties across the wall at each setting.

By this process a compound wall comprising two leaves of 4½ inches of brickwork interleaved with a 3-inch wall of water-proofed concrete has been formed.

Probably this method of building may sound elaborate, but is really quite simple in construction and efficacious in use.

Tanking a Basement

There are, however, many other ways of building basement walls that will ensure watertightness; and they, of course, are considerably more expensive.

One of these methods is to build the walls in the same manner as previously described, only in this instance a narrower space is left—say, 1½ inches—which is filled up with a molten mixture of equal parts of pitch, tar and sand after every five courses have been built. When the mixture

in the cavity has set or solidified, the brickwork can be continued.

As soon as the wall is 9 inches clear of the ground level, the remainder of the wall may be built up as solid brickwork; this will mean a reduction in the thickness of the wall from 10½ inches to 9 inches.

Either of the foregoing methods of building walls below ground level is applicable to such work as garage pits, weighbridges, and so on.

Subsoil Drains

It is very desirable that, when and where possible, the ground should be well drained by means of agricultural or subsoil drains so as to relieve the water pressure on the walls and floors.

This system of drainage is simplicity itself. All that is necessary is to dig a trench from the pit to an open water course, so that the bottom of the trench has a slight gradual fall away from the building. Into this cutting place drain tiles—or, as they are sometimes called, drain-pipes ; which are unsocketted and unglazed, and made from earthenware—not stoneware. These tiles are rarely, if ever, made longer than 1 foot and are 3 inches, 4 inches or 6 inches in diameter.

Laying these tiles is quite a simple operation.

Having bottomed or straightened the bed of the trench, place the tiles in a direct line, leaving a space of about ½ inch between each pipe, and cover them over with any coarse material such as broken bricks, shingle, ashes or furnace refuse for about 2 feet, and then replace the excavated soil.

On the completion of the filling-in of the trench, an amount of surplus soil will remain; this should not be removed from the site because all soils expand when excavated, and after a while they contract almost to their original density. Therefore it is advisable to heap up the surplus soil on to the top of the trench and allow it to weather down to its normal level.

For walls which are built below ground level, it is recommended that a good type of brick, possessing a fairly dense character, should be chosen. The brick should be absolutely free from lime and may be made from shale providing that it does not contain carbon in any appreciable degree.

As previously mentioned, the subsoil effluent should be emptied into a water-course. In a built-up area this may not be practicable and the subsoil water may have to be disposed of into a foul sewer.

This condition is liable to lead to complications unless a few simple rules are observed. Firstly, the subsoil water should enter the manhole as near as is possible to the ground level and the foul-sewer invert should be as low as possible so that the maximum vertical distance is obtained between the level of the two drains. Secondly, the chamber should be adequately ventilated to prevent the collection of foul gases which may pass along the drain and, by escaping from the open joints of the drain tiles, create a nuisance. Lastly, it is advisable to insert an interceptor in the subsoil drain at the point of entrance to the drain.

CHAPTER XI

ROOF COVERINGS AND REPAIRS

ALTHOUGH the trade of slating and tiling is not—strictly speaking—bricklayers' work, most bricklayers are able to deal with this work in a satisfactory manner.

It is not intended, however, to go into all the details of slating and tiling in this volume, but rather to deal with as much of the subject as will enable the learner to cover a small roof such as for an outbuilding or a private garage.

Practical Slating

Slating consists of laying and fastening slates upon battens in such a manner that, under normal conditions, they will form a watertight roof. Slates should be always cut so that their length is equal to double their width—except in one or two exceptional cases—so that there are many sizes, from twenty-four twelves to sixteen eights—or, as the text-books have it, all the female ranks in the peerage.

There are two ways of securing slates to the battens—one is by nailing them at their head, and this process is known as "head" nailing, and the other one is by nailing them half-way down their sides, which is known as "centre" nailing. To secure the slates to the battens, it is advisable to use the galvanised iron nails which are specially sold as slate-nails. Should copper nails be available, they are to be preferred to the galvanised iron ones.

The first row, or course, of slates is always shorter than the rest of the normal courses—that is to say, about $1\frac{1}{2}$ inches greater than half the full length of a normal slate, the width remaining the same.

These slates are called "eaves" slates, and slates of a similar size are used for the last course in much the same manner and are called "ridge" slates

Making the Gauge

Before a roof can be covered with slates—or tiles—it is necessary to work out a convenient gauge or spacing between the supporting battens. The battens are strips of wood from 12 feet to 18 feet in length, varying in size from $1\frac{1}{2}$ inches by $\frac{3}{4}$ inch to $2\frac{1}{2}$ inches by $1\frac{1}{8}$ inches, and they regularise the coursing of the slates.

The gauge is also the same as the margin, or exposed surface of the slates.

Another point to remember is that the lap of a slate is the amount by which it covers the head of the slate in the course next but one below. To find the "gauge" for the battens, make the following calculations as for 18 inches by 9 inches slates laid to a 3-inch lap :—

Centre Nailing :

$$\text{Gauge} = \frac{\text{length} - \text{lap}}{2}$$

$$= \frac{18 \text{ in.} - 3 \text{ in.}}{2} = 7\tfrac{1}{2} \text{ inches.}$$

Head Nailing :

$$\text{Gauge} = \frac{\text{length} - \text{lap} - 1}{2}$$

$$= \frac{18 \text{ in.} - 3 \text{ in.} - 1 \text{ in.}}{2} = 7 \text{ inches.}$$

Head nailing is a weaker form of slating than centre nailing on account of the long leverage which tends to cause the slates to lift in a high wind. Head nailing is slightly more expensive than centre nailing because the gauge is usually $\frac{1}{2}$-inch less.

Never make the pitch of the roof less than $37\frac{1}{2}$ degrees, otherwise the wind may catch the tails of the slates and rip them off or drive the rain underneath them.

Commence to lay a course of slates by placing the slates in succession, using the batten as a guide to the

horizontal, and nail each one as the work proceeds until the course is completed. The next course should be laid so that the tails of the slates are centrally over the joint between any two of the slates in the course underneath, and this entails the employment of either a half-slate or a slate-and-a-half slate at the commencement of each course at each end.

As their names imply, a half-slate is a whole slate which has been split equally down its length and is now only half of its original width, and a slate-and-a-half slate is a slate which has been cut, at the quarry, to include an extra half-slate width. The lengths of these slates will remain the same (20 inches), but their widths will now be 5 inches and 15 inches respectively. Altering the widths in this manner produces an effect similar to stretcher-bonding in brickwork.

Holing the Slate

Hole the slates by placing the slate upon a brick or an iron dog, and give it a sharp tap with the pointed end of a bricklayer's scutch on the wrong side of the slate.

Cutting the Slates

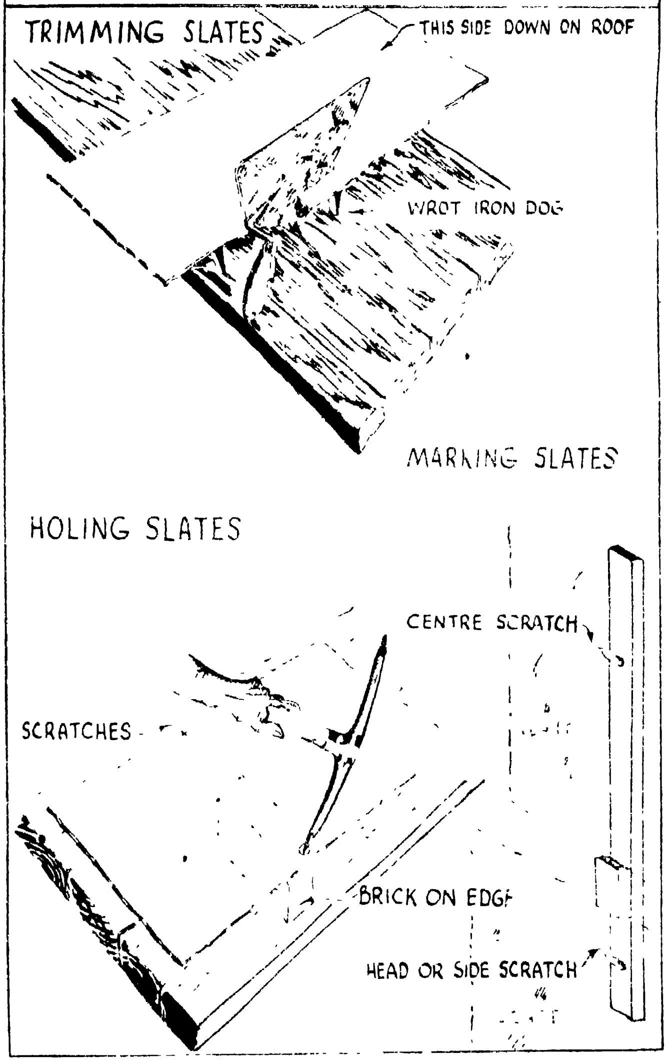
Similarly, to cut a slate, place it on the support as before for holing, and then strike it with the edge of the laying trowel; if it should be too thick or too hard to cut easily, then a series of holes must be made with the pointed edge of the scutch, and it will then break away very freely.

Repairing a Cracked Slate

To repair a cracked slate, raise both pieces of the slate very carefully with a laying trowel and insert a piece of sheet zinc, which should be as long as the margin plus the allowance for the nail hole, underneath the broken pieces.

It is imperative that the cracked slate should be lifted first because the weight of all the other slates which are above it will be pressing it down and the zinc will be pre-

PLATE XXX. TRIMMING AND HOLING SLATES



vented from sliding underneath and it will tend to buckle up or tear apart.

Repairing a Fallen Slate

As the slate-nails rust or break away, the slates will begin to drop, and to make an effective repair job it is first necessary to remove the slate altogether, thus exposing the batten to which the slate in the course below had been nailed. To this batten nail a copper or lead strap so that it hangs about 2 inches below the tail of the slate to be repaired. Now replace the slate by sliding it into position and then turn the end of the strap *over* the tail of the slate so as to prevent the slate from dropping out of position.

The foregoing—cracking and slipping—are the two most common defects in slating with a description of the usual methods of effecting a repair.

There are other defects which are likely to arise in connexion with a slated roof, such as the breaking away at mitred hips and the dislodgement of ridge tiles; but as these are fairly straightforward matters, their repair does not call for any explanation. All that is required is the replacement of the ridge tiles. There is quite a similarity between slating and tiling as the tiles are set out, arranged and laid in the same manner as for slates. Repairs are also effected in much the same manner.

Practical Tiling

Plain tiles are, roughly, 10½ inches long by 7 inches wide. They are smaller than the smallest slate, consequently the gauge for the battens is considerably less—which is, as a rule, from 2½ inches to 3½ inches.

There are many special tiles used for roofing and they are made to fit various parts of the roof.

Tiles are made artificially from a plastic material; therefore, it is possible to mould and shape them to fit into positions to which slates could never be applied, as it is practically impossible to obtain any shape other than the thin flat sheets of slates, because they are split from a natural rock.

Tiles, like slates, may be nailed to the battens, but this method is not to be recommended as a careless tap with the hammer will break the tile. Tiles—that is, plain tiles—should be wired to the battens by passing a wire through the nail hole, around the batten, and fastening the two ends underneath by twisting them together.

Repairing a Fallen Tile

When replacing tiles that have slipped from their correct position, it may be considered advantageous to get inside the roof-space and to pull the new tile upwards and between the existing tiles by means of a piece of copper wire which is then threaded around the batten. Secure the tile by twisting the wire as before.

It is not advisable to use lead straps to support the tile, as recommended for slates, but zinc interlinings may be used as these have no appreciable thickness which may cause the tiles to rock on the ones underneath.

Some types of plain tiles are fitted with two small projections at their head, and these form an integral part of the tiles and are called nibs. Nibbed tiles are to be preferred to those without nibs as they will support themselves without nailing or wiring. This is because the nibs act as claws by catching on to the upper edge of the batten.

Defects in Tiled Roofs

Roofs which have been made with nibbed tiles are very difficult to repair. The most common defects of plain tiles are: (*a*) lamination; (*b*) tail splitting, and (*c*) vertical cracking.

Lamination is a disintegration of the material due to the action of sulphuric acid upon faulty material. Tail splitting is caused by the action of frost upon the water contained underneath the tail of the tile. Vertical cracking is due to the tile not resting evenly upon either the batten or the tiles underneath it and subjected to greater pressure on one side than the other.

Good plain tiles are always made with a longitudinal camber which prevents most of the foregoing troubles.

There are many other types of tiles such as pan tiles, Roman tiles, interlocking tiles and so forth. The methods of forming roof coverings with the various forms of tiles are illustrated in the volume on roofing in this series.

One of the most important considerations when tiling or slating a roof is to give the tiles or slates a good lift at their lower edge, or eaves, by means of a tilt-fillet or fascia board and, most important of all, see that there are always three thicknesses of tiles or slates over each batten.

Slates have a further use in the formation of damp-proof courses and tiles may be put to a further use—that is, to shed water clear of walls at copings, etc.; and this is known as "creasing."

Floor Tiling

So much for roofing.

We will now discuss another aspect of tiling—that is, floor tiling, which is often considered as part of the bricklayer's craft.

First of all, a good foundation for the tiles is needed, and this is best made by forming a layer of concrete at least 4 inches thick. The longer it can be allowed to remain before covering it with tiles, the better, because any subsequent movement in the concrete, whilst it is setting, will also affect the finished tiled floor. Nothing can be done to prevent any movement once the concrete begins to set, as it will move and pull the tiles with it. Therefore, to minimise the movement of the concrete, or perhaps to localise the movement, the concrete should be laid in bays not exceeding 6 feet by 6 feet and provided with expansion joints.

There are many forms of expansion joints, one of the most effective being formed by placing a $\frac{3}{8}$-inch board between two of the bays which is removed before the concrete on both sides of it has set. To ensure good results, the hole may be left clear and afterwards a strip of brass or similar metal, which has been doubled to form a flattened

U shape, may be placed with the rounded end uppermost, to coincide with the height of the finished tiled surface. Metal expansion rods save a great deal of trouble when laying the floor because they can be used as screeds or guides to which the tiles may be subsequently laid.

If, however, metal expansion rods are not available, the screeds must be run either in cement, or they may be formed of slate battens when there is to be no specially tiled margin. Should it be necessary to form a tiled margin to the floor it is advisable to complete this first and then to use the margin as a screed for the main portion of the tiling.

The way to run a screed is to level a dot from the threshold or the finished floor surface, by using a piece of tile bedded on to some mortar, and by levelling from this dot, place two more dots at the ends of each long wall.

Between the two dots, place the mortar in a line. Level the mortar with a long parallel rule or straightedge until you have formed a continuous flat prism of mortar extending along the floor and down both sides of the room. When they are set, these two strips of mortar will support the rule, and by using it in this manner it will be possible to estimate the amount of mortar that will be required to bed the tiles by placing a piece of tile so that its upper surface coincides with the under edge of the straightedge. Next, spread a patch of mortar, consisting on three parts of sand and one part of cement, on the floor in an even manner

For this purpose use the back edge of a laying trowel and allow the mortar to set until it is in a semi-plastic condition

To piece up to the wall, or to run a margin, lay a board on its flat side, and weight it down with bricks so that it cannot move, and then drop the tiles on to the bed and gently push them up to the board. Continue this process by placing the tiles as closely as possible on the bed until the tiles are in their final position.

It is absolutely essential to have the bed as level as possible and to keep the tiles perfectly close to one another whilst they are being laid. All that is required is to place the tiles directly into position.

Do not slide them on to the mortar bed if it is possible to avoid it, and do not allow any room for a mortar joint between the tiles as when finished they should not show any mortar, the joint being skin-tight. Keep the tiles up to the rule, and should they be too high give them a sharp tap with the handle of the trowel, at the same time easing the surrounding mortar bed accordingly.

When all the tiles have been laid they should be allowed to set, and this will take some considerable time as the tiles are soaking wet through, having been saturated preparatory to being laid. Do not mistake the drying of the tiles for the setting of the mortar bed, because, although the tiles may still have a damp appearance, they may be firmly set.

Upon the surface of the partially set tiles pour some grout —which is Portland cement mixed to the consistency of cream—then brush the grout well into the joints with a soft hair sweeping-brush. Repeat the process by adding a thinner grout until it is not possible to brush any more of it into the joints.

When the grout has almost set it may be cleaned off in one of two ways, firstly by washing off the cement grout which has lain upon the tiles with water and a sweeping brush; or, secondly, by covering the whole of the tiles with sawdust. In the first case, the application of the water tends to wash a little of the cement out of the joints, although by keeping the tiles wet over a long period a better and more rigid surface is obtained. In the second case the sawdust absorbs the moisture out of the grout and as it is swept away it has a scouring effect upon the remaining cement causing the tiles to dry before they are thoroughly set.

Repairing a Loose Tile

Sometimes a tile may work loose, and to repair it one of two things may be done. Either

(*a*) soak the tile and its surrounding joints with water until it is saturated, and then brush some grout into the joints, trying to get a little underneath the tile if possible ; or

(*b*) lift the tile from its neighbours by using two trowels as levers—chisels are too thick for this purpose—then cut away the old bed and clean the side joints and then the bed of mortar should be re-laid. Next replace the tile and finally apply the grouting as before.

Wall Tiling

In some respects the process of tiling a wall surface is similar to that of floor tiling. For instance, a bedding surface must be obtained by screeding with mortar to receive the tiles. To do this it is necessary to screed the wall and to coat, or to render it, with a layer of Portland cement mortar so that it presents a flat and untwisted surface. This process is called "*flanking*" *the wall.* A rule must now be prepared as a guide to the finished tiled surface which, being vertical, is a rather more difficult operation than forming the horizontal bed for the floor.

The tiles should be saturated before they are laid—then take a tile in your left hand and butter the back of it with mortar and place it as near as possible in position. Allow it to rest upon its lower edge, keeping the side close up to its position against the adjoining tiles, then tap the tile home with the handle of the trowel.

A good craftsman will place the tiles into their correct position by a pushing movement with the left hand and will not allow the mortar to creep in between the tiles. Should the mortar get between the tiles the joint will become too thick and it will be impossible to keep the tiles in their correct line with one another and the joints will be uneven.

Make sure the tiles are as near as possible in their correct position as they are set, as it is fatal to the work to attempt to knock them back or to bring them forward. Having completed the tile-fixing rub the surface of the tiles with a skimming of Keene's cement and this will make a good finish to the job by filling in the surface of the joints.

When the cement has almost set it should be cleaned from off the tiles with a clean dry cloth.

Jointing Between Woodwork and Brickwork

Pointing the joint between the window and door frame and the wall is always a difficult operation because ordinary mortar will not adhere to wood or metal. It is advisable therefore when making good the joint between wood and metal frames and the surrounding brickwork to use a special pointing material. The most common of all such materials is known as "mastic" cement, which is a mixture of silver sand, litharge and linseed oil. As the material is rather expensive it should be used very sparingly and carefully.

Clean all the mortar out of the joint and then press the mastic cement into the cavity, and when it is certain that the joint is completely filled, add a little more mastic to the surface of the joint in excess of that normally required. When the packed joint has been "roughed" in this manner, smooth the mastic down with a pointing trowel or a special jointer so as to form a flat finished joint.

To form a marginal joint place a plasterer's lath down the side of the frame and lightly resting upon the joint, and then by running the point of the trowel down the edge of the lath a nice parallel line will be formed. Apply the trowel to the brickwork and gently scrape away the surplus mastic to finish the job.

Instead of using a lath you may form a triangular fillet with a jointer tool which will produce a finished surface of half-an-inch or, if desired, three-quarters of an inch.

To prevent draughts, the mastic should be run all around the openings and the metal window frames. Also the joint between the window bottom and the stone or brick cill should be filled with mastic cement as a special precaution against the damp penetrating.

It is also considered good practice to point the joints in the brick cill with mastic cement.

Air-bricks and Ventilation

Another feature of construction with which a beginner must concern himself is the provision of a means of the ventilation of rooms, floors, drains, etc. Normally this is accomplished by building air-bricks into the walls and flues which have direct access to the open-air.

Air-bricks are usually made from brick-earth in the shape of a hollow brick the face of which is perforated to a pattern. The holes do not pass through a solid brick—it is only the shell of the brick which is perforated on the face.

Some air-bricks are made of cast-iron and some are home-made with pieces of tiles, but in every case they should be relieved of the weight of the brickwork above. This statement mainly applies to large gratings of 9 inches by 9 inches and more, whereas the usual small gratings of 9 inches by 3 inches are so small that resistance to compression may be ignored.

When setting air-bricks make sure that the hole on the inside of the wall is covered with a piece of slate to support the brickwork which lies on the top of it. To do this, trim a piece of slate (as described in roofing repairs) to the width and allow for a seating on the brickwork of at least 3 inches on each side of the hole and bed it very gently by rubbing it down into the mortar. When laying the bricks on the top of the slate care must be exercised or the slate will crack and possibly collapse.

Cast-iron or concrete boxes which enclose mica-flap ventilators are now made for ventilating manholes, but these require no special instructions as there will be no weight placed upon them.

CHAPTER XII

SPECIAL BRICKS

External Angle Bricks

UP to the present we have only discussed the manufacture and uses of ordinary common bricks, but there are many other special shapes and sizes of bricks which are made to suit many different purposes.

The most common purpose of these "special" bricks is to ease the sharp external angles of pilasters and stopped ends so as to prevent the sharp arrises from being snipped and broken.

When the angle is rounded off the brick is called a "Bulnose," which may be of any radius from $1\frac{1}{8}$ inches to $4\frac{1}{2}$ inches. Bricks which have a reverse curve are called "Cove bricks" and these are mainly used for internal angles.

Next in order of popularity is the "Chamfer" brick—which is generally cut at $2\frac{1}{4}$ inches from the corner to form a splayed surface which is uniform at 45 degrees. There are many other angle bricks such as "Mop-staff Beads," "Reeds" and "Rolls."

Moulded angles begin and finish with a square angle and to do so another special brick is needed which is called a "Stop." The most important thing to remember with regard to stops is that they are handed—that is, made to fit the right hand and the left hand. Make sure that you get the hand required for the particular piece of work upon which you are engaged.

Reduction Bricks

As walls are increased in height so they are proportionately reduced in thickness, and to accomplish this a special brick called a "Plinth" is used. Plinths are special bricks which are bevelled on their face to a slope

of 45 degrees, thereby reducing the top bed by 2¼ inches. Also, these plinth bricks are produced in many other shapes and sizes, external and internal returns, external and internal stops, and so on.

Weathering Bricks

Cills and copings need special bevelled surfaces to act as watersheds and they should be made with a groove for a water-bar in the case of a cill brick and with a groove on the underside to form a throating in both cases. These lower edges should always be made to project beyond the face of the wall.

The purpose of the grooving is to prevent the water from running down the face of the cill or coping and under the projecting lower edge continuing down the face of the wall underneath the protective brickwork. When there is no groove, the bevelled brickwork only partially acts as a watershed. The groove interrupts the flow of the water because of its inability to flow uphill. This grooving is called throating, and a substitute for it may be obtained by placing plain tiles with their nibs facing downwards underneath the bevelled bricks that have not been grooved.

Other Special Bricks

There are special bricks used for other purposes such as arches, sewers, floor paving, string courses, bases and so on, but they will not be discussed here as they call for an amount of exceptional training in order to lay them.

There is not much difficulty in laying special bricks—that is, where they act as a substitute for common bricks on angles—the chief points of interest being as follows: instead of holding the plumb-rule about 1 inch from the corner as is normally done, it must now be held 3 inches from the corner. Place the plumb-rule so that it is on the flat portion of the brickwork and not on the moulded part of the brickwork.

When levelling cill and coping bricks keep the top arris of the bricks in line and level by means of a straightedge.

But, if the bricks are not regular and true to shape and if the bricks are projecting past the face of the wall the top must be treated as a secondary consideration. This latter procedure is necessary, because the bottom arris is the eye line.

There are several methods of building solid walls as well as building hollow walls with bricks and hollow terra-cotta tiles.

Hitherto I have only dealt with 4½-inch, 9-inch, and 12-inch solid walls, and now we will consider hollow walls.

CHAPTER XIII

SPECIAL WALL CONSTRUCTION

Cavity Walls

IN the normal way a cavity wall is built for three reasons :

(*a*) to prevent the conduction of moisture through the porous brickwork of outside walls.

(*b*) to provide thermal insulation, and

(*c*) to provide acoustic insulation.

The usual method of construction is to build two 4½-inch walls with a 2-inch space between them. At no time should either wall or leaf of the compound wall come into actual contact with the other.

Although we must observe this condition a means of obtaining mutual stability must be provided. This is usually accomplished by fixing horizontal ties of metal or bricks at frequent intervals during the building process throughout the wall area.

To do this, the outside leaf is built up for four or five courses in height, and then it is left and work proceeded upon the inside leaf which is raised to a similar height. It is at this level that the metal ties are placed upon the brickwork across the cavity at intervals not exceeding 1 yard.

Proceed with the work as before and then place another series of tie irons across the cavity in such a position that they will be midway between the ties previously laid. As this process is continued the wall-ties will be staggered vertically.

Ensuring a Clean Cavity

One of the most important points that a bricklayer had to consider during the building of the cavity wall is the prevention of mortar droppings collecting at the base of the cavity, or upon the wall-ties and window and door

frame heads. If this precaution is not observed, then the whole value of the cavity will be lost when the mortar solidifies. Obviously, then, the cavity must be protected by some form of covering.

One method is to obtain a long band of straw which is about 2 inches in diameter, which has been securely bound, and to which cords have been attached at intervals. This straw band is rested upon the ties and the cords drawn out in such a manner that they rest upon the inner leaf of brickwork. The outside face work is raised for five courses, and then the cords are lifted and placed on the top of it. Then the inside face work is raised and the straw band raised to the top of the cavity. On reaching the top, the band is raised clear of the brickwork and subsequently cleaned of mortar.

Transverse Tying

When this has been done the tie-irons may be laid and the work proceeded with as before.

A similar method is to use a slate batten instead of a straw band, preference being expressed for the straw band as it is more pliable and will give way to any undue regularities in the width of the bricks, whereas a batten will catch underneath a projection and either hold fast or dislodge the green brickwork.

A fault often experienced with cavity walls is that the mortar droppings are apt to collect upon the tie-irons when the foregoing precaution is not taken, and this may be prevented in part by inserting the laying trowel into the cavity and smoothing the joints of the inner leaf rather than leaving them to exude and project. *N.B.*—Golden rule: Keep the cavity clean.

Cavity walls should always be adequately ventilated, and this may effectively be done by inserting air-bricks at the base and the top portion of the wall. The top of cavity should always be effectively sealed by running a course of headers along the top of the wall just underneath the wall-plate.

Sealing of Ventilators

Also, the enclosing of ventilators is a point that must not be overlooked. They should be totally enclosed by boxes made from pieces of slate which are carried across the cavity so that the stagnant air in the cavity does not enter into the room through its ventilator.

Rat-trap Bond

Another very popular form of temporary building is called " Rat-trap bond." In effect it is a type of Flemish bond cavity walling with the difference that the bricks are set on " edge " and not on their " flats." This arrangement allows for a 3-inch cavity when the middle stretching brick is omitted and the header forms the tie across the wall.

For temporary, or even permanent, buildings this method of brick building has everything to recommend it ; it is speedy in erection, cheap, takes less material, has all the advantages of a cavity wall and is almost as strong as a solid wall of the same thickness.

The only point to which exception may be taken is that on the exposed face the bricks appear on their edge instead of, as is more usual, their bed.

If it is desired, the wall can be turned into a combined wall by filling in the cavity with concrete instead of leaving it empty.

CHAPTER XIV

MEASURING BRICKWORK

THE calculations for brickwork are based upon the surface measurement of the wall multiplied by the thickness of the wall, and the process is called *reducing the brickwork.*

In the south of England the standard of measurement for brickwork is the *rod,* which is the amount of brickwork contained in a wall of 272 feet super. and 1½ bricks thick, whilst in the north of England the standard of measurement is the *yard,* which is the amount of brickwork contained in a wall of 9 feet super. and 1 brick thick.

The Standard Rod of Brickwork

A standard rod of reduced brickwork will have a superficial area of 404 feet super. or 45 yards super. (approx.) if the wall is 1 brick thick, 272 feet super. or 30¼ yards super. (approx.) if the wall is 1½ bricks thick (this is the standard rod), or 204 feet super. or 22⅔ yards super. if the wall is 2 bricks thick.

There are 306 cubic feet or 11⅓ cubic yards in a solid piece of brickwork equal to a standard rod.

One rod of brickwork laid to a gauge of 4 courses to 11½ inches requires 4,530 bricks. One rod of brickwork laid to a gauge of 4 courses to 1 foot requires 4,350 bricks.

The lineal land measure of the rod, pole, or perch of 5½ yards is the basis of the standard rod, which is the original rod squared and thicknessed. So that we have a wall 5½ yards long and 5½ yards high by 1½ bricks thick or 16½ feet long and 16½ feet high by the same thickness, but in practice 272 square feet by 14 inches in thickness is the standard figure, and this is usually taken. On Plate XXXII the diagrams illustrate the comparative lengths of walls having a constant height of 10 feet and varying thicknesses from 1 to 2 bricks. It will be obvious that the thinnest wall will provide the largest area or what is known in the

PLATE XXXI. THE STANDARD YARD

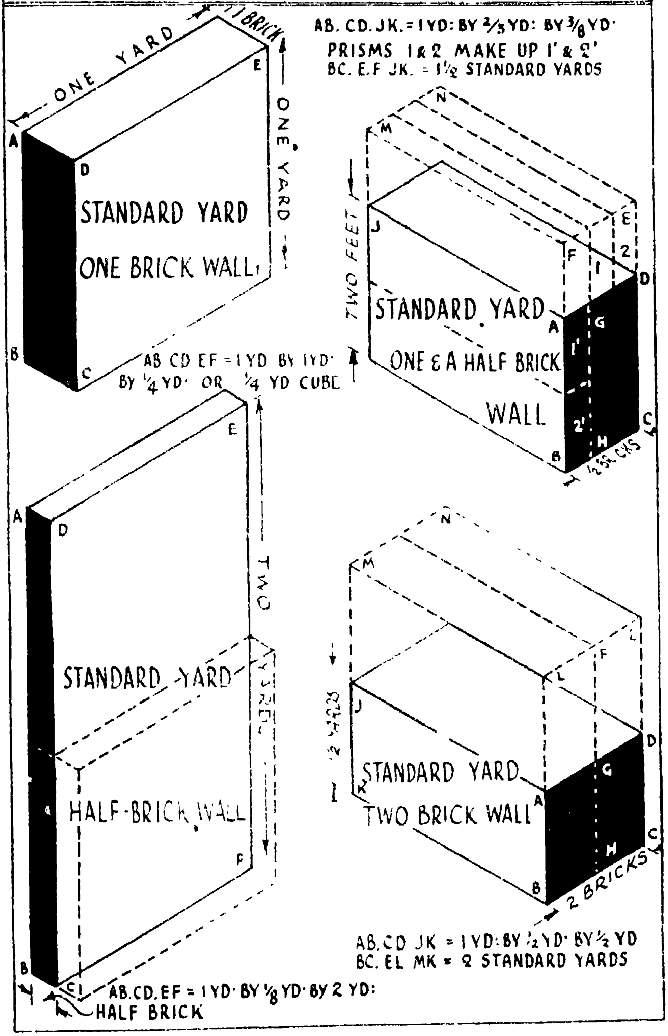
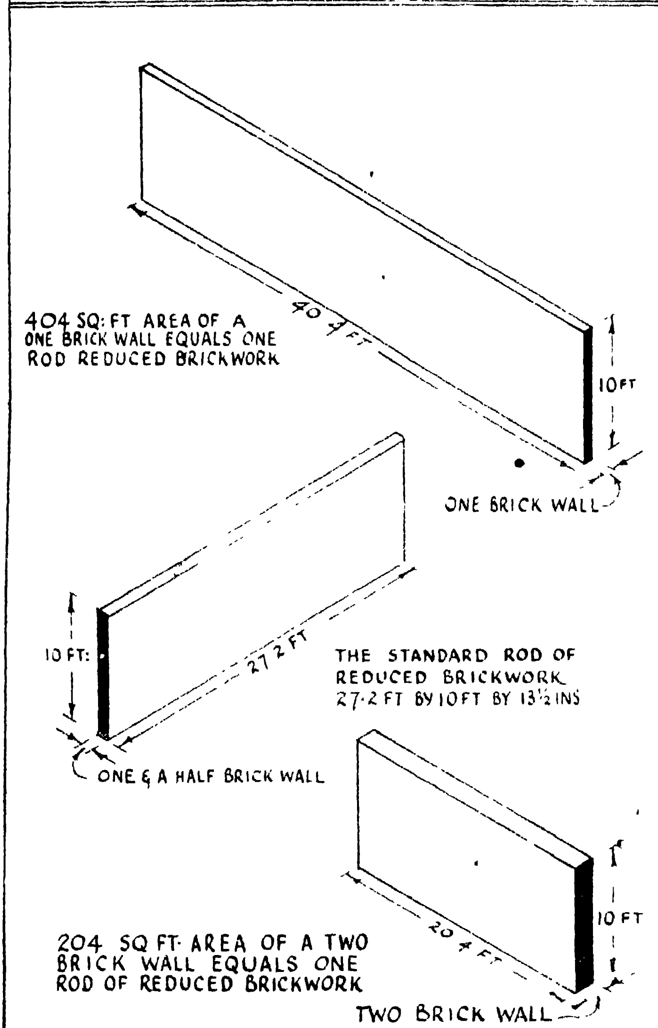


PLATE XXXII. THE STANDARD ROD



trade as "seen face," whilst the thickest wall is reduced to half the length of the former.

When considering walls and thicknesses it is very important to remember that when a wall is opened out or extended the work involved is increased proportionately. Let us take the standard example of a wall 1½ bricks thick with an area of 272 feet super. When built in a wall 1 brick thick the area is increased by almost half as much again, whereas a wall 2 bricks thick is reduced to three-quarters of the original area respectively.

It is easier to build a wall with a relatively small face in conjunction with the maximum amount of brickwork; consequently, it is more economical to build a thick wall than a thin one.

This is illustrated on Plate XXXIII. The lower sketch indicates the amount of wall area in the standard rod of 1½ bricks; the height being 15 feet and the length 18 feet 1½ inches which, of course, is approx. 272 feet super. If both faces of this wall are to be left fair and pointed there will be 544 feet super. of seen face.

Next we will discuss the upper diagram. This diagram represents a wall of the same length and breadth, but each of its half-brick thicknesses has been opened out to form a separate leaf so that in all there are 1,632 feet super. or three times the area for the same number of bricks or cubical content.

If you study the middle illustration last it will be seen that in this block the *standard rod* has been reduced to as compact a mass as is conveniently possible. Here there are two faces of 44 feet super. and two faces of 42 feet super. making a total of 172 feet super. or nearly one-third of the original seen faces.

This alteration of the wall area does not affect the cost of the bulk of the materials, but it does influence the labour costs very considerably. For instance, a certain amount of extra labour is involved in plumbing and levelling during the process of the erection of each separate square-head, and this takes about the same time—within reason—for

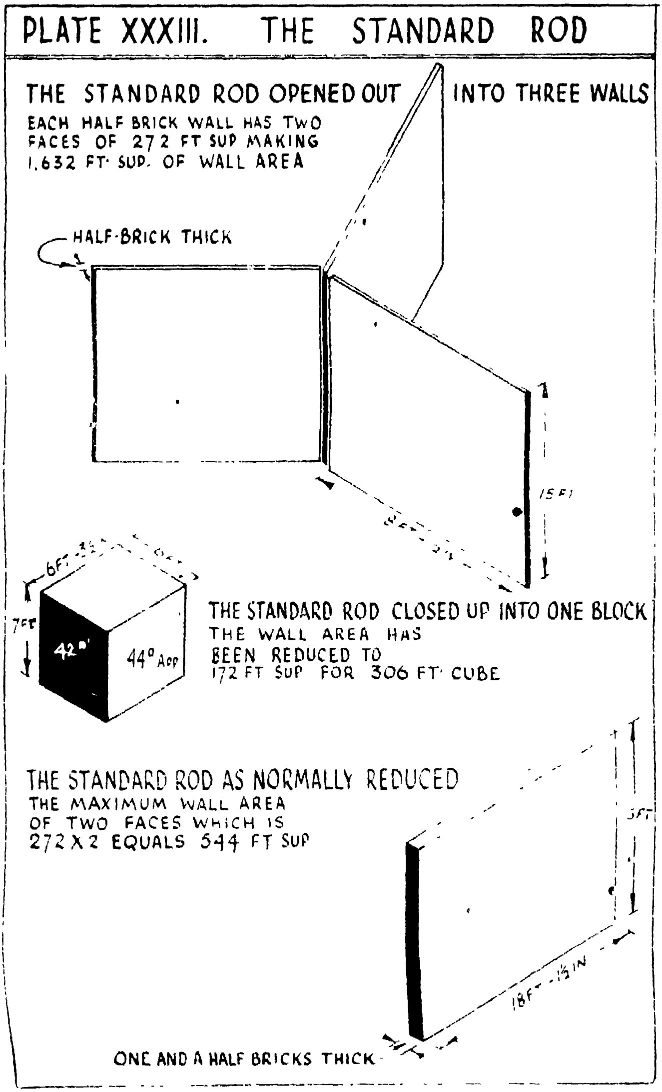


PLATE XXXIII. THE STANDARD ROD
THE STANDARD ROD OPENED OUT INTO THREE WALLS
EACH HALF BRICK WALL HAS TWO FACES OF 272 FT SUP MAKING 1,632 FT. SUP. OF WALL AREA
HALF-BRICK THICK
15 FT
6FT
7FT
THE STANDARD ROD CLOSED UP INTO ONE BLOCK
THE WALL AREA HAS BEEN REDUCED TO 172 FT SUP FOR 306 FT. CUBE
THE STANDARD ROD AS NORMALLY REDUCED
THE MAXIMUM WALL AREA OF TWO FACES WHICH IS 272 X 2 EQUALS 544 FT SUP
18FT-1½IN
ONE AND A HALF BRICKS THICK

one as for another. Then there is the working to the line for the face work, which must be kept fair on one or both sides. Lastly, there is the finish to the work in so far as pointing is concerned.

If the work is to be executed in special facing bricks, obviously the greater area will necessitate the use of more of these higher-priced bricks with a corresponding reduction in the use of the common bricks.

Also, greater areas will need more scaffolding and this will tend to increase the cost of the brickwork in a cumulative manner.

Obviously, then, the cost of reduced brickwork is a very arbitrary figure and it is very important to remember that it is bulk work, therefore the character of the work must have an overriding influence when computing the cost of reduced brickwork and is usually classified as "*extra over.*" All incidentals should be jotted down as extras for pricing, but in order to obtain this information a certain amount of practical acquaintance with the work will be necessary.

To find the amount of brickwork in standard rods, multiply the area of the wall in square feet by the fraction

$$\frac{\text{thickness of wall}}{\text{thickness of } 1\tfrac{1}{2}\text{-brick wall}}$$

and divide the result by 272. From this it will be seen that a wall of 272 feet super. 4½ inches thick will contain exactly ⅓ of a standard rod.

For an ordinary wall not more than 6 feet high 1½ bricks thick, without openings or breaks, the cost may be analysed as follows :

	£	s.	d.
4,400 bricks, 75/- per 1,000	16	10	0
2¼ yards cube cement mortar (3:1), 40/- per ton	4	10	0
Bricklayer, 70 hours, 2/- per hour	7	0	0
Labourer, 35 hours, 1/6 per hour	2	12	6
	£30	12	6

This estimate is only approximate as prices are continuously changing, but the constants are on the conser-

vative side. For instance, a margin of 50 bricks, ¼ yard cube of mortar, about 3 hours for the bricklayer and 1½ hours for the labourer are allowed for waste on account of inclement weather or other stoppages.

Incidentally, it is worth mentioning here that one labourer will serve two bricklayers, whilst they are working on the ground level; but when working on a scaffold one labourer can only serve one bricklayer.

It will be apparent from the foregoing that it is quicker and cheaper to build a 1½-brick wall which is nominally known as 14-inch work—than a 1-brick wall, or even a ½-brick wall, because there is less face work per brick used in the wall. Every ½-brick thickness will have two faces of 272 feet super., making 6 × 272 feet super. of face work in a standard rod, and a 1½-brick wall would only have a total of 2 × 272 feet super. of face. This is explained by the diagram.

The Standard Yard of Brickwork

The standard yard of reduced brickwork will have a superficial area 9 feet super. if the wall is 1 brick thick (this is the standard yard) or 18 feet super., or 2 yards super., if the wall is ½ brick thick, and 6 feet super., or ⅔ yard super., if 1½ bricks thick. This is explained by the diagram on Plate XXXI.

The number of bricks required for a standard yard of brickwork when set to a gauge of 4 courses to a foot is 96. When northern bricks are used the gauge is usually 7 courses to 2 feet, as the bricks are nominally 3⅜ inches thick. The number of bricks required for a standard yard of brickwork is 84, or 1,000 bricks to every 12 yards.

A bare analysis of 1 standard yard of brickwork is as follows:

	£	s.	d.
84 bricks, 75/- per 1,000		6	4
1 cwt. lime mortar, 23/4 per ton		1	2
Bricklayer, 1 hour, 2/- per hour..		2	0
Labourer, ½ hour, 1/6 per hour			9
		10	3

The same conditions apply to this estimate as those for the standard rod and should only be used as a typical example under the prevailing conditions. Furthermore, no addition has been made for profit. As this amount may be taken as 15 per cent. of the nett cost, we would normally add 1s. 6d. to the 10s. 3d. and the total cost per standard yard would be 11s. 9d., and the 15 per cent. increase when added to the nett cost of £30 12s. 6d. for the standard rod of brickwork would amount to £35 4s. 6d.

As the wall rises, the speed of the work begins to slow up, and as a result the cost per standard yard or standard rod will be proportionately increased. It is the labour costs which cause the increase; the material costs remain the same, whilst the small amount of material that is wasted may be ignored.

The 15 per cent. previously mentioned is usually an adequate allowance, not only for profit but for incidental items such as scaffolding, plant, insurances and the like.

Extra Costs

For the purpose of estimating the cost of building a wall, *all* the brickwork is measured as solid work, irrespective of the class of bricks which are to be used, the finish to the wall surface, the number of openings, and so on. Usually, the difference between the ordinary brickwork mass and the special labour is distinguished by the description "*extra over*," and this was dealt with when we considered the rod. Therefore, the basic price is always for ordinary brickwork—or reduced brickwork.

The most common of all items for adding to the reduced brickwork is that of facings. The term *facings* means that a different type of brick has been used for the outside face of the wall from that which is used for the mass of the wall. Facing bricks may be glazed, sand-faced, sand-lime, London stocks, or any other type of brick which is used for a facing purpose.

A few typical examples may be taken at random to illustrate what is meant by *extra over*. Supposing the wall

is built in Flettons and lime mortar and is one-brick thick, the cost would be 8d. per foot super. for labour only, or for labour and materials, 1s. 6d. per foot super. Now, if the best bricks are chosen out of the stack for the face work, the cost of the face work will go up another 3d. per foot super. totalling 1s. 9d. per foot super. for the wall, and this price includes a charge for hand-picking or selecting the bricks.

When a different type of brick is used the additional cost is as follows :

	s.	d.
Rustic Flettons		5
London Stocks		7
Luton Greys	1	0
Ruabon Red Stocks .. .	1	6
Blue Staffordshire.. .. .	1	6
Salt-glazed	3	9
White-glazed	4	0

To find the value of *extra only* on facings, take the difference in shillings per 1,000 between the building bricks and the required facings—divide by 10 for English bond, or by 12 for Flemish bond, and the result will give the price in pence and fractional parts per foot super. For example, taking St. Helen's common bricks at 75s. per 1,000 and Accrington Red Stocks at 120s. per 1,000, the difference is 45s. per 1,000. This divided by 10 gives 4½d. per foot super. to which must be added at least one penny for the pointing to pay for this extra labour. As previously explained and illustrated on Plates XXXII and XXXIII it is possible to make walls of varying superficial areas by using the same amount of brickwork, but altering the thickness. This was applied to the standard rod, and in Plate XXXI we see it applied to the standard yard.

On Plate XXXI the left upper diagram illustrates the conventional standard yard of 1 yard × 1 yard × 1 brick thick. This gives 2 yards super. of seen face or ¼ yard cube.

Underneath this is a sketch of a standard yard as applied to a $4\frac{1}{2}$-inch wall. Obviously, the new area will be exactly 4 yards super. of seen face.

At the top right of the plate an example is given illustrating the contracting of the surfaces by increasing the thickness of the work by another half-brick. The wall remains 1 yard long, but its height is now reduced to $\frac{2}{3}$ yard and the seen face becomes reduced to $1\frac{1}{3}$ yards super. If the wall was to be built to form a prism 1 yard $\times$ 1 yard $\times$ $\frac{3}{8}$ yard, as indicated by the dotted lines E F, M N, B C, K B, this would be exactly half as much again, or $\frac{3}{8}$ of a yard cube.

The lower right-hand sketch illustrates a standard yard of brickwork—when the wall is increased to 2 bricks thick. It must be reduced to $\frac{1}{2}$ yard in height if the length is to be maintained. This means that the seen faces are now $\frac{1}{2}$ yard super., whereas if the prism was raised to a height of 1 yard and its base area remained the same there would be 2 standard yards of reduced brickwork contained therein.

N.B.—In dealing with standard yards it is advisable to keep all the measurements in yards and parts of yards.

More Data

A bricklayer's hod is usually 1 foot 4 inches long and 8 inches $\times$ 8 inches in section or—as the labourer terms it—an 8-inch diamond. There is really no limit to the number of bricks that can be placed in a hod, but the number will depend upon the manner in which the bricks are boxed. In normal circumstances the labourer will carry 8 bricks in the "box" whilst climbing a ladder or doing dangerous work, and when walking on firm ground he will carry 10 bricks in the hod quite comfortably and without fatigue for an 8-hour day These are the usual amounts which, of course, may occasionally be exceeded.

There is a slight difference in the number of bricks required for the same area when different face bonds are employed, a common allowance being that of 7 bricks and

8 bricks for 1 foot super. of Flemish bond and English bond respectively.

1 foot super. of reduced brickwork requires 16 bricks.

1 foot super. of gauged arches requires 10 bricks.

1 yard super. of brick-nogging requires 48 bricks laid on flat.

1 yard super. of brick-nogging requires 32 bricks laid on edge.

1 yard super. of paving requires 32 bricks laid on flat.

1 yard super. of paving requires 48 bricks laid on edge.

1 yard super. of paving requires 9 12-inch × 12-inch × 2-inch tiles.

1 yard super. of paving requires 16 9-inch × 9-inch × 1½-inch tiles.

1 yard super. of paving requires 36 6-inch × 6-inch × ¾-inch tiles.

19 heaped or striked bushels equal 1 yard cube.

1⅓ cubic feet of mortar equals approximately ½ bushel. Lime and Portland cement require about ⅓ of their bulk of water to mix.

Lime and sand, and cement and sand lose about ⅓ of their bulk when made into mortar.

Labour Costs

As I have previously stated a thorough working knowledge of the trade is necessary before it is possible to form any basis or schedule of prices that will serve to obtain the cost so as to estimate the value of the work. A good average day's work on a 9-inch wall for one bricklayer is 700/800 bricks or about 8 yards. Now, if one face has to be struck, this will mean that for almost 1 hour the bricklayer will be putting the finish on to the work, leaving 7 hours for actual bricklaying, thus bringing the number of bricks down to 600/700. When both faces of the wall need pointing, the output will be further reduced.

Doorways, window openings and any details such as pilasters, plinths, string courses, etc., must inevitably slow

up the bulk of the work, and these walls are accordingly more expensive to build brick for brick.

Likewise, the laying of D.P. courses, wallplates, lintels, and so on, interferes with the normal progress of the work, which should always move with a definite rhythm.

Another point worthy of special attention is that circular work, such as cutting to arches, gables, etc., is carefully noted and measured and charged for along with the other extra items.

Other Extras

There are many other items of brickwork which will require extra labour, items that are not straightforward, such as: corbelling, oversailing, string courses, label moulds, joining new work to old, raising new work on old work and so on. Also the running of copings, tile creasings and the raking out of joints for flashings are items of major importance and must always be allowed for.

CHAPTER XV

ARCHES AND ARCHING

In ordinary brickwork there are only two types of arches to be met with; they are the *rough segmental* arch and the *gauged* or cut semi-circular arch.

Of course, there is the popular "soldier" arch; but this is not an arch in the true sense of the word. It is really a joggled lintel.

To conform to the definition of a true arch, it should be composed of members which mutually support each other and disposed about the form of some curve.

Arch Terms

The principal terms connected with an arch are as follows:

Span.—The horizontal distance between the two supports.

Rise.—The vertical distance between the springing line and the highest part of the underside or soffit of the arch.

Springing line.—A level line between the commencement of the arch and the supporting brickwork.

Springer.—First brick in arch.

Skewback—The impost or support for the sides of the arch.

Face.—The elevation of the arch, the area contained between the intrados and the extrados or the soffit and the back of the arch.

Soffit (or intrados).—The under-surface or ceiling of the arch.

Back (or extrados).—The upper surface of the arch.

Key.—The brick which is placed centrally upon the centre line.

Half-brick ring.—Row of bricks showing heading faces only.

Rough arch.—Arch composed of untrimmed bricks.

Axed arch.—Arch composed of rough-cut hard bricks.

Gauged arch.—Arch composed of finely cut soft bricks or specially made hard bricks.

Abutment (or squarehead).—The brickwork supporting the arch.

Rough Segmental Arch

This is the most common of all brick arches and it is used in every type of construction from house building to civil engineering. Because it forms a part of a circle and because it is composed of half-brick rings, it is the simplest and easiest of all brick arches to build.

It is set out by drawing the springing line and the centre line and setting of the rise which, as shown on the illustration on Plate XXXV, is 3 inches. A chord line should be drawn between the rise and the springing point and bisected. This bisecting line should be continued to cut the centre line; the intersection of these two lines will be the centre for striking the arch curve.

This construction is founded on a well-known geometrical principle.

Having obtained the centre, draw a radial line passing through the springing point, and this line produced will be the skewback line, and the angle made by this line and the springing line will be the pitch of the skewback.

It is important to ascertain this pitch beforehand as the skewback must be built at the same time as the main brickwork. This is necessary so that the brickwork may set and become solid before the arch is filled in. If the skewbacks are not cut to the correct level the arch bricks will not lie comfortably upon the wood center, and any attempt to drive them into position will cause the displacement of the other bricks.

At no time should the key—or for that matter any other arch bricks—be knocked into position with a hammer. Always make the bricks take up the position by correct spacing. Never have the joints too tight or too slack. Do not attempt to set the bricks with an easy wide joint,

hoping to "wedge up" the arch by a good flushing of the joints, or by ramming mortar into the joints with the edge of the trowel, as this is as fatal as setting the bricks too tight.

Again, do not build the arch in a haphazard way—remember a successful arch construction depends upon the even spacing of the bricks.

It is considered good practice to commence the building of rough arches by placing a full brick on the skewback, and not as is shown in the sketch. When there are two or more half-brick rings in the arch this is possible, but in many cases there is only one half-brick ring in the arch.

This arch is symmetrical, and to set it out or to draw it there is no need to draw the full arch as both halves are the same. Likewise, when building, the work should be commenced simultaneously from both skewbacks, preferably by two workmen. If only one man is available, then he should work alternately with each brick from side to side. At no time should there be more than two bricks on one side of the wood center than on the other side, otherwise the arch will become unbalanced.

Earlier in this chapter it was stated that the skewbacks should be built before the arch is "filled in." Also the brickwork should be raised above the level of the top of the key. Raising the intermediate brickwork in this way will provide a substantial support for the straight-edge when it is applied to the face of the arch during the "filling in" process. For convenience, the intermediate brickwork may be toothed.

When the bricks in the arch have been "keyed-in," the ordinary courses may be "made up" by cutting the bricks over the arches and levelling the work up to the height of the intermediate work which was built previous to the "filling-in."

Sometimes the bricks have to be reduced to very long attenuated pieces, as shown next to the centre line in the diagram (Plate XXXV). Only an expert is capable of making such a cut successfully, therefore the learner is

advised to make the piece from two separate halves. Separating the pieces in this manner will not raise any serious objection provided the pieces are equal in length.

However, this "cutting over" to the arches is not so simple as it looks on the drawing, and the instructions given on pages 54-60 for cutting bricks with the lump-hammer and bolster, and for trimming with a brick-hammer should be carefully observed and carried out.

It may be difficult to reconcile the name "rough" arch when it is in reality an important piece of craftsmanship, and one which requires a certain amount of skill. An arch of this description should be—when completed—as presentable as the remainder of the brickwork. The description *rough* means the bricks used in the arch are not cut or trimmed to any shape or pattern. They are simply left in their original condition.

This means that they present their rectangular ends to view. At first it is not realised that it is the mortar joint which, being wedge-shaped, enables the bricks to be disposed about the curve or arc.

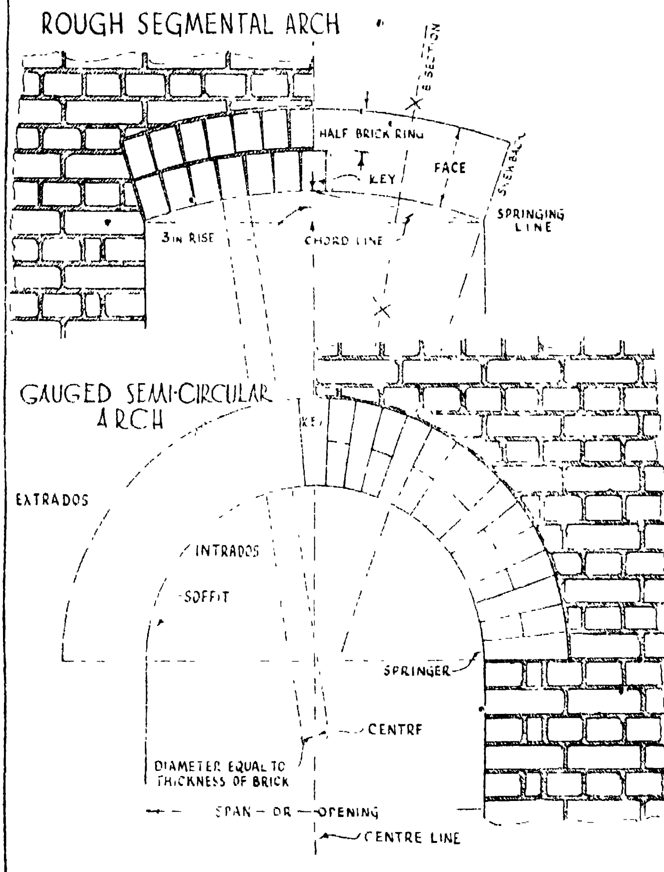
Axed Arches

There are cases where—for the sake of appearance—the bricks are cut and rough trimmed to the wedge-shape of the voussoirs. Such arches are called *rough axed* arches. These arches are more expensive to construct on account of the extra time taken in cutting the bricks to the prepared templets. Axing is a relic of olden times, as the brickaxe was the forerunner of the present-day brick-bolster.

It is well-nigh impossible to cut axed arches from such bricks as Ruabon Red stocks or Pressed Staffordshire Blue engineering bricks, and one or two other varieties. In such case it is advisable to send the detailed drawings to the brick manufacturers to have the bricks specially manufactured. This is particularly economical if there are to be many repeats, as the cost is considerably reduced thereby.

PLATE XXXV. BRICK ARCHES

SIMPLE ARCHES STRUCK FROM ONE CENTRE



Gauged Semi-circular Arches

An example of one of these arches is illustrated in Plate XXXV. The arch has a span of 3 feet between the jambs of the bricks and a clear rise of 1 foot 6 inches as well as a gauged brick face 9 inches deep. Obviously, the radius of this arch curve is 1 foot 6 inches and does not require the elaborate working out that was necessary for the rough segmental arch curve.

As in the case of the previous example of a segmental arch, only half of the arch need be set out.

To make the bricks for this arch it is necessary to obtain the correct templet, and this is applied to the face of the uncut bricks so that the correct shape may be scribed upon it. In effect, the face of this arch is half the annulus between a circle of the inferior diameter which forms the intrados, and a circle of the superior diameter which forms the extrados.

The bricks are set out by spacing them on the extrados or back of the arch. From these equal divisions, lines are drawn across the face of the arch which are normals to the curve and radial from the centre. The shapes thus obtained by the converging lines being applied to the face of the bricks are parts or frustums of wedges.

From this it will be seen that the arch-bricks or voussoirs, as they are sometimes called, will form an arc by themselves without further assistance from the mortar joint which will be parallel in its thickness. This mortar joint should be kept as thin as possible to match gauged work in general.

These two examples of arches are struck from one centre and so they should be keyed in with a brick. This means that a brick should be so placed that the centre line of the arch would pass through the centre of the brick, in much the same way that there should be a keystone if this type of arch was constructed in stone.

Soldier Arches

Reference has already been made to the fact that this

form of covering to openings is not a true arch ; it is in fact a joggled lintel. This statement may not be quite true because all soldier arches are not joggled. In most cases they are simply bricks placed on their end—hence the name soldier.

As the soldiers are not mutually self-supporting, some other means of support must be provided. Very often the bricks are bedded direct on to the wooden frames or lintels. Sometimes they are supported on flat, mild steel bars, or angle or channel sections. Earlier types of this arch were reinforced by mild steel rods which passed through perforations in the bricks and later types are supported by special nibs on pre-cast concrete lintels.

There is not much to be said about the appearance of this feature except that it is typical of the straightforward trend in modern design.

Timber Centers

Arching bricks over an opening is not a job that can be successfully accomplished without a certain amount of training, and the best way to learn is to partner an experienced bricklayer during the actual covering over. Confidence is a requirement of the first order when building an arch, as a nervous or uncertain workman may cause the arch to shake and so collapse.

During the building of the arch the bricks are usually supported on timber. These wooden supports are of two kinds : (1) turning pieces and (2) lagged frames.

Where the rise is not excessive, say 1 inch in 1 foot—as in the segmental arch—the support could be made from a piece of timber 4 inches × 2 inches × 3 feet long. That is if the soffit, or underside, is only $4\frac{1}{2}$ inches deep. For a 9-inch soffit, or more, the center would best be made from two pieces of wood lagged across to allow the bricks to rest comfortably.

A lagged center must of necessity be used for the semicircular arch irrespective of the width of the soffit. These lagged centers are made from 1-inch boards framed to-

gether so as to conform to the shape of the arch curve. Pieces of wood 1 inch × 1 inch, termed laggings, are placed on the framing, the top surface of the laggings completely filling the opening.

When bedding the bricks do not allow any mortar to squeeze out and get between the center and the brick.

CHAPTER XVI

BRICK BONDING

THERE are two patterns of orthodox bonding used in this country; one is *English bond*, the other is *Flemish bond.*

English Bond

has the reputation of being the strongest arrangement for the bricks, and great reliance is placed upon this bonding for it is used on most civil engineering projects. Certainly it has not yet been known to fail—of itself.

Return Quoins

Plate XXXVI shows the details of the plans and elevation of a 9-inch and a 14-inch right-angled corner of a brick wall built in *English bond.*

The most important points to note are (1) the header is not on the same level as it turns the corner; (2) the same elevation obtains for any thickness of wall; (3) the collar joint always runs straight through with the heading course; (4) the brick that ties the angle is always a header or a part of the heading course; (5) all toothers should be headers; (6) the bond is quarter-bond ; (7) there is always $2\frac{1}{4}$ inches lap.

In this bond, courses of headers alternate with courses of stretchers, the bond being broken by the insertion of a queen closer next to the quoin header.

As previously stated, all external elevations of return quoins are the same, but the internal elevations change every time a half-brick is added to the thickness of the wall. This will be seen by the lower sketch elevation on Plate XXXVI.

The greatest practical difficulty about English bond is that it is very slow to build because every time a header is run it must be backed up before the next face course

Sectional Bond

There are two ways of building Flemish bond; one is as shown on Plate XXXVIII, which is known as *sectional bond*, and the other, not shown, is known as non-sectional bond. In sectional bond the joints run right through the wall. These joints are known as *cross-joints* or *transverse joints*.

When the cross-joints do not pass in an uninterrupted line across the wall, then the bond is termed non-sectional, and the headers have a closer on each side in the middle 4½ inches of the wall and not a half every two headers, as is shown by the plan of the 14-inch return quoin on the lower sketch.

Stopped End

There is not much difference between the stopped end of the *English bonded* walls and those built in *Flemish bond.* Instead of all headers coming together on the inside of the wall there is a header and then a stretcher on one course, and a three-quarter and then a header as shown in the plan in Plate XXXIX.

English Garden-wall Bond

There are many derivatives of the two orthodox brickwork bonds, the most popular and useful pattern being that known as the *English garden-wall bond.*

First of all you must not forget that it is *English bond*—even if it is altered. The most important alteration is that heading courses are omitted from the wall, these headers being substituted by stretchers.

In the example shown on Plate XL there are three courses of stretchers to one of headers. There are many cases of four and even five courses of stretchers together.

Ordinary 9-inch walls do not present much difficulty if the middle stretching course is laid so that it forms half-bond on the course below, and backed up in a similar manner. Thus every cross-joint in every course is sectional.

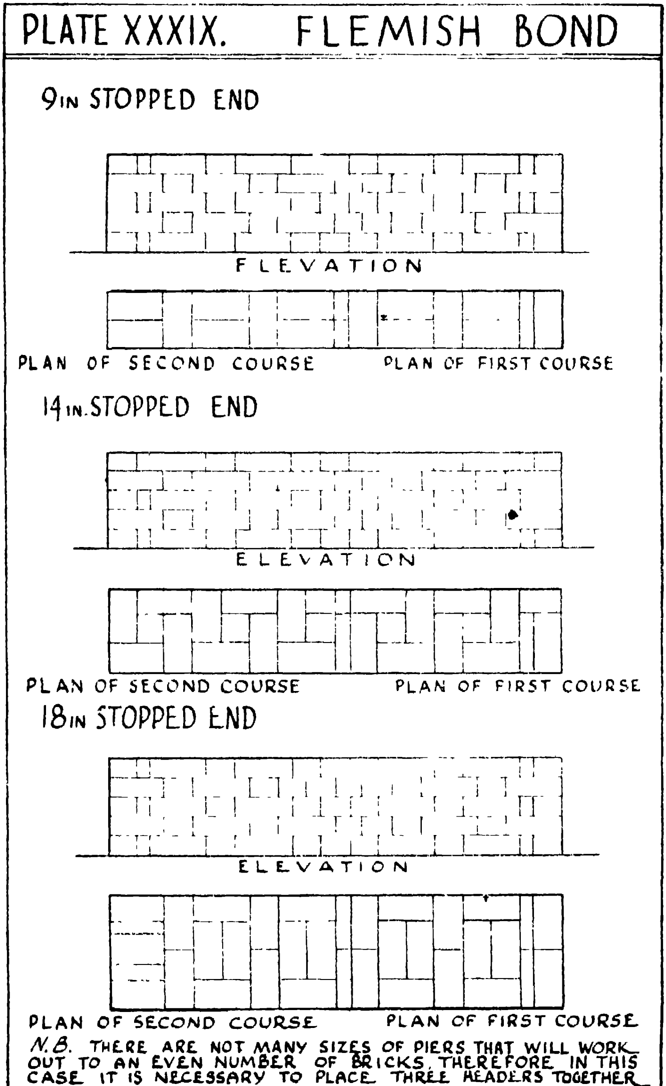


PLATE XXXIX. FLEMISH BOND
9IN STOPPED END
ELEVATION
PLAN OF SECOND COURSE
PLAN OF FIRST COURSE
14IN. STOPPED END
ELEVATION
PLAN OF SECOND COURSE
PLAN OF FIRST COURSE
18IN STOPPED END
ELEVATION
PLAN OF SECOND COURSE
PLAN OF FIRST COURSE
N.B. THERE ARE NOT MANY SIZES OF PIERS THAT WILL WORK OUT TO AN EVEN NUMBER OF BRICKS, THEREFORE IN THIS CASE IT IS NECESSARY TO PLACE THREE HEADERS TOGETHER

PLATE XL. ENGLISH GARDEN WALL BOND

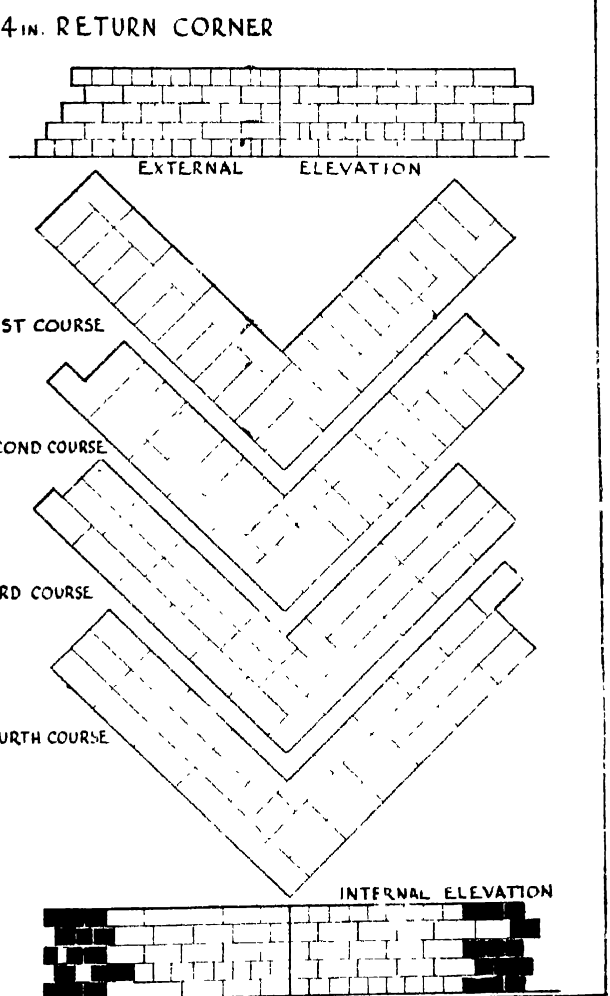
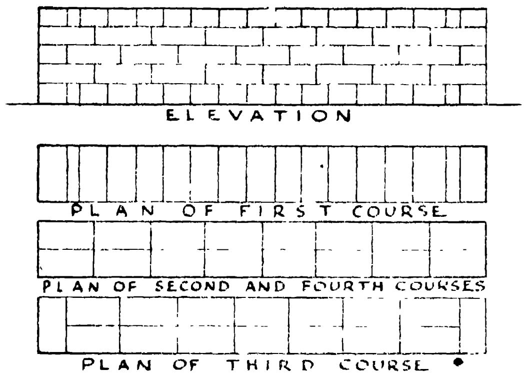
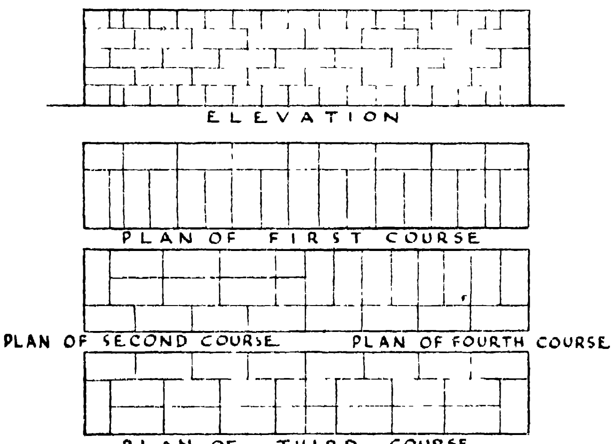


PLATE XLI. ENGLISH GARDEN WALL BOND

9IN: STOPPED END



14IN: STOPPED END



N.B. CONTINUOUS VERTICAL COLLAR-JOINTS WILL BE UNAVOIDABLE BUT SECTIONAL BOND MUST BE MAINTAINED

When the wall becomes increased in thickness, trouble arises because, in order to provide the maximum number of through cross-joints, the bond of the middle stretching course, on the inside of the wall, is only quarter-bond. This is different from the face, which is always half-bond (*see* the lower sketch on Plate XL).

This is undoubtedly the most intricate of all common bonds and it is well worth a careful study.

Stopped Ends

The stopped ends in *English garden-wall bond* follow in much the same way as in *English bond*, but attention is again directed to the complex plan. Note carefully that in a 9-inch wall the second and fourth courses are identical in plan. Not so, however, in the 14-inch wall, because, whilst the face stretcher is the same on these two courses, there is a stretcher and header backing up the second and fourth courses respectively.

Flemish Garden-wall Bond

This bond is very similar to English garden-wall bond. The same principle applies, that is, the substitution of stretchers for headers. In the case of *Flemish garden-wall bond* the stretchers are placed in pairs or threes between the headers in each course.

There are two reasons for eliminating headers; one is that laying headers slows up the progress of the work and the other is that in 9-inch work, which has to be finished with a struck joint, the headers must be selected for length which, of course, is a costly process. So for sake of economy in time and materials, the headers are omitted in favour of stretchers.

There are many other brick patterns or bonds, but the subject is too exhaustive to be fully discussed in this book.

The subject of bonding may not have been treated in the usual manner of text-books for building construction, but the subject has been considered from the point of view of a learner of the trade.

CHAPTER XVI

CAVITY WALLS

HOLLOW walls have in general three advantages ascribed to them as follows : that they are damp-proof, that they are sound-proof and that they possess certain advantages in respect to thermal insulation. Let us consider the moisture repellent qualification first. It is to be assumed that the wall is built with two half-brick leaves, which are tied together at various intervals, usually about half a yard from each other when spaced diagonally. A much more satisfactory wall is made when the inner leaf or supporting wall is 9 inches thick and the cloak wall or outer leaf is 4½ inches thick ; but as this is the exception rather than the rule, it will not be considered here.

Upon the outer leaf of the wall rests the responsibility for the water-tightness of the complete wall, and as this is of a half-brick in thickness, soundness of construction is imperative. Local bricks, as would be used in the case of a solid wall, will most probably be used.

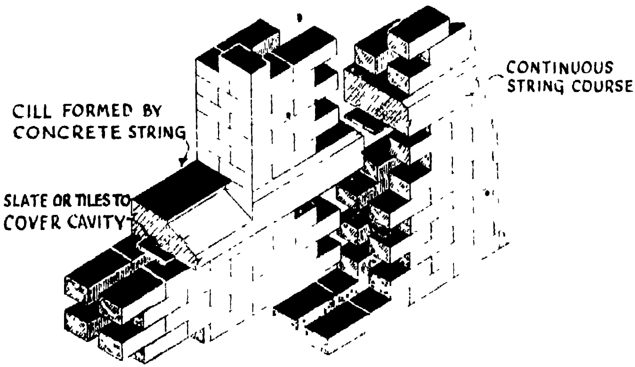
Equally of importance is the strength of the mortar; even more so, as the bed and cross-joints are of so little depth, and this without the rebutting value of the collar-joint. However, a good ordinary mortar will supply all the qualities required for this class of work.

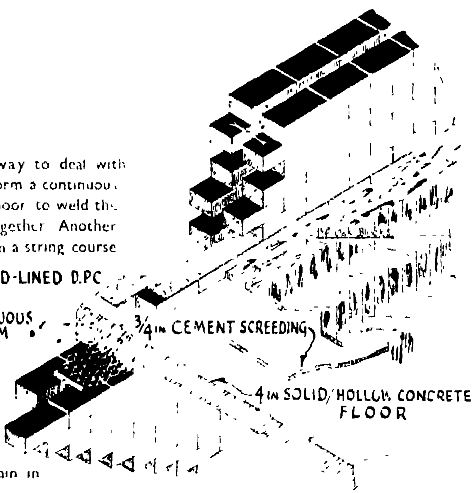
Wall Ties

For purposes of stability, ties from one wall to the other are necessary to provide mutual support. These ties are many and varied in pattern and material. Wrought-iron straps, 6 to 7½ inches long, by 1 inch wide and about ⅛ inch thick, having various twists or devices to prevent the passage of the moisture across the space, are generally used. There is, of course, the familiar bow-shaped wire tie, which has proved its efficacy. On the better-class

PLATE XLII. CAVITY WALLS

Continuous Concrete Beams for Cavity Wall Construction





A very satisfactory way to deal with cavity walls is to form a continuous concrete beam or floor to weld the whole of the block together Another suggestion is to form a string course of concrete either in situ or precast in long lengths When formed in situ the cavity may be sealed with a roofing batten or waste pieces of slates &c, and allowed to remain in position

work bronze on gun-metal has been used in preference to wrought iron. This latter is well worth the extra expense as it is practically imperishable and can be relied upon, whereas the iron ties, whether they be galvanised, tarred or sanded, or sherardised, cannot be depended upon. When a cavity wall, only ten years old, was demolished quite recently the cavity was devoid of all vestige of connexions, although the ends remained securely bedded in the mortar joints. Sometimes pieces of impervious bricks (blue or red) are used as ties, as also are the patent stoneware tiles.

Sealing the Joints

Providing that the mortar, bricks, and ties are of a good quality, there only remains one source of conductivity and that is by timber frames, or the exposed joints between the frame and the brickwork. Defects of this nature can be prevented by proper bedding and pointing the joint with mastic on completion, remembering always that the frames are placed in flush jambs without rebates. A straight line of drift is thus provided for the penetrating rain or snow. This leads us to a consideration of the sealing of the cavity at the jambs which, obviously, cannot be the placing of the wood frame centrally in the opening. Even if this is done the fixing of steel frames will not blind the opening. Effective sealings may be made in the first place by bonding the brickwork with a three-quarter bat in the reveal, secondly by bedding tiles or slates in the cavity, and thirdly by a patent cavity cill and weather bar assembly. All the best books on building are agreed that all wood frames should have their heads protected by damp-proof courses, and sheet copper or lead is usually advocated, but a strong case has been made out for their non-inclusion. There are thousands of houses in the north of England built without any provision for such imaginary protection, and many pounds saved thereby. This tends to make one think that the authorities are liable to get well out of their depth in their theorising.

Mortar Droppings

The outstanding weakness or cause of failure in cavity walls is the evil habit of carelessly allowing mortar droppings to accumulate on the transverse crossing of the tie iron or to collect in the bottom of the cavity. To overcome this difficulty slate battens may be laid upon the tie irons and lifted when each setting has been run. Straw bands and McKenzie's patent wall cores are other contraptions which may be used just as effectively. Another way to minimise the risk of a collection of droppings on the tie irons is to use an ordinary piece of sheet copper or brass placed edgewise between the cross-joints. Supplementary to this is the Hay patent wall tie.

Ventilation

Thermal insulation is affected by the ventilation or otherwise of the cavity. For instance, if the cavity is completely sealed, the interior (rooms) temperature is isolated from the outer (open) air by the vertical buffer of air between the conductors—the brick walls. Whereas if the cavity air be in direct contact with the outside air, then any heat insulatory value will be considerably reduced. Ventilation of the cavities is very often insisted upon by some local authorities, and when this is enforced, the induced air may be diverted to pass through the enclosed under-floor space and back into the cavity and then out through the top ventilator into the open air again. At least it is conjectured that such is the case. The general practice is to provide an air-brick at the base and another at the top, as this provision induces an upward movement of the otherwise stagnant air. Having no air-bricks in the outer leaf means that the imprisoned air has little or no movement and becomes mouldy. One of the most important things regarding ventilation is to ensure that the air-bricks connecting ventilators for bathrooms, W.C.s, and rooms in which there is no permanent flue outlet, are completely sealed or " boxed off " from the cavity. Indeed, this must be done to comply with the regulations which

state that the air in the room shall be in direct contact with the outside air.

Factors Governing the Proper Use of Cavity Walls

In the opening remarks it was stated that the combined wall of two separate half-bricks would be considered, and this construction is good enough except in the following circumstances:

(*a*) The height of the external wall exceeds 25 feet.

(*b*) The floor is subjected to heavy loads.

(*c*) The site is exposed and extra thermal insulation is desired.

(*d*) The thrusts are likely to be of an inclined nature, when any one of these conditions demands a 9-inch inner leaf.

Conversely it will be noted that the superincumbent weight of the structure is supported by a simple half-brick wall deficient in actual strength and not likely to be looked upon with favour. External walls less than 9 inches thick were tabooed by the building authorities before the war, when the regulations, owing to war-time requirements, were somewhat relaxed.

The popularity of the cavity wall has been primarily influenced by constructional and theoretical considerations, but *it has been positively governed* by the practical operational facilities obtainable under the system. That is, a five-, six-, or seven-course setting can be run in one performance; then the line can be reversed for the backing up of the face courses, the tie irons arranged and another setting built exactly as before. Advantage is thus taken of the fact that it is easier and quicker to run courses of stretchers than to lay headers. Corners or heads are easily prepared as they can be taken up to a scaffold height before the line is run. Finally, I would say that the crux of the matter is the *modus operandi*.

INDEX